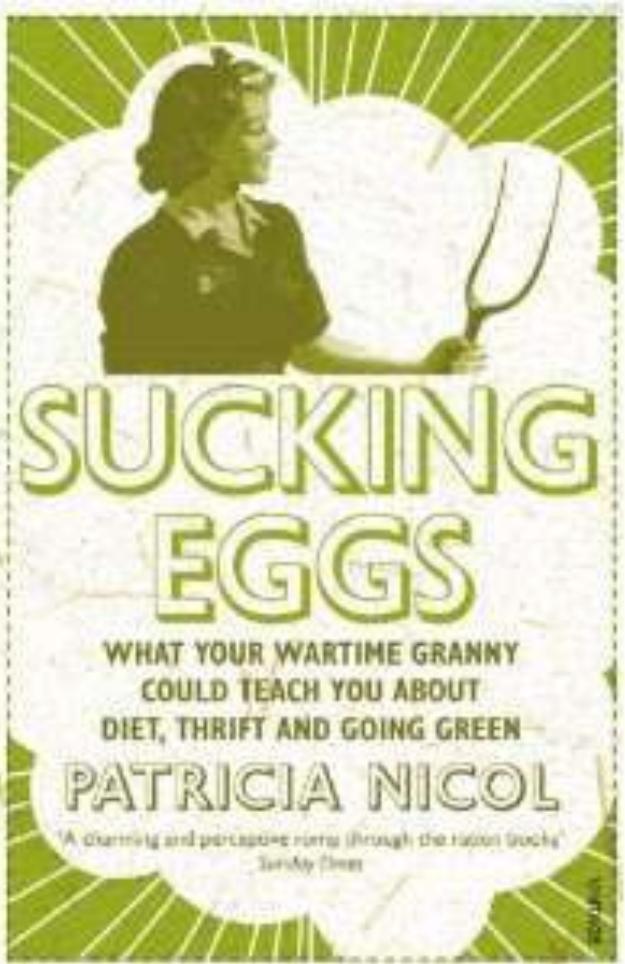


# Work Breakdown Matrix

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# Learning objectives



# Method



# Who am I?



- Professor of Management  
Swinburne University of Technology
- Visiting Professor of Construction  
Unitec New Zealand
- Director – Micro Planning International
- Designing underlying theory for LBMS and developing applications
- SBEnc Program Director 2010-2015

# Introduction

## Issues

- Project decomposition is important
- WBS is a well developed method
- Its been with us now 55 years
- Is it time to revisit?
- Current methods are repetitive and hard work
- Project control remains a problem
- There is a better way

## Proposal

- Need to go back to basics
- Recognise the role of location
- Extract location from the WBS
- Use a Location-work breakdown matrix
- Redesign PM processes and software!

# Development of WBS

## History

- Designed into the US Navy Polaris Missile project in 1957
- Defined and published by 1962 in DoD Guide to PERT
- Codified into a standard in 1968 in US MIL-STD-881
- Adopted in DEF(AUST)5664 (1995) and Rev A (2004)
- Developed as a practitioner's tool for project decomposition

## What is it?

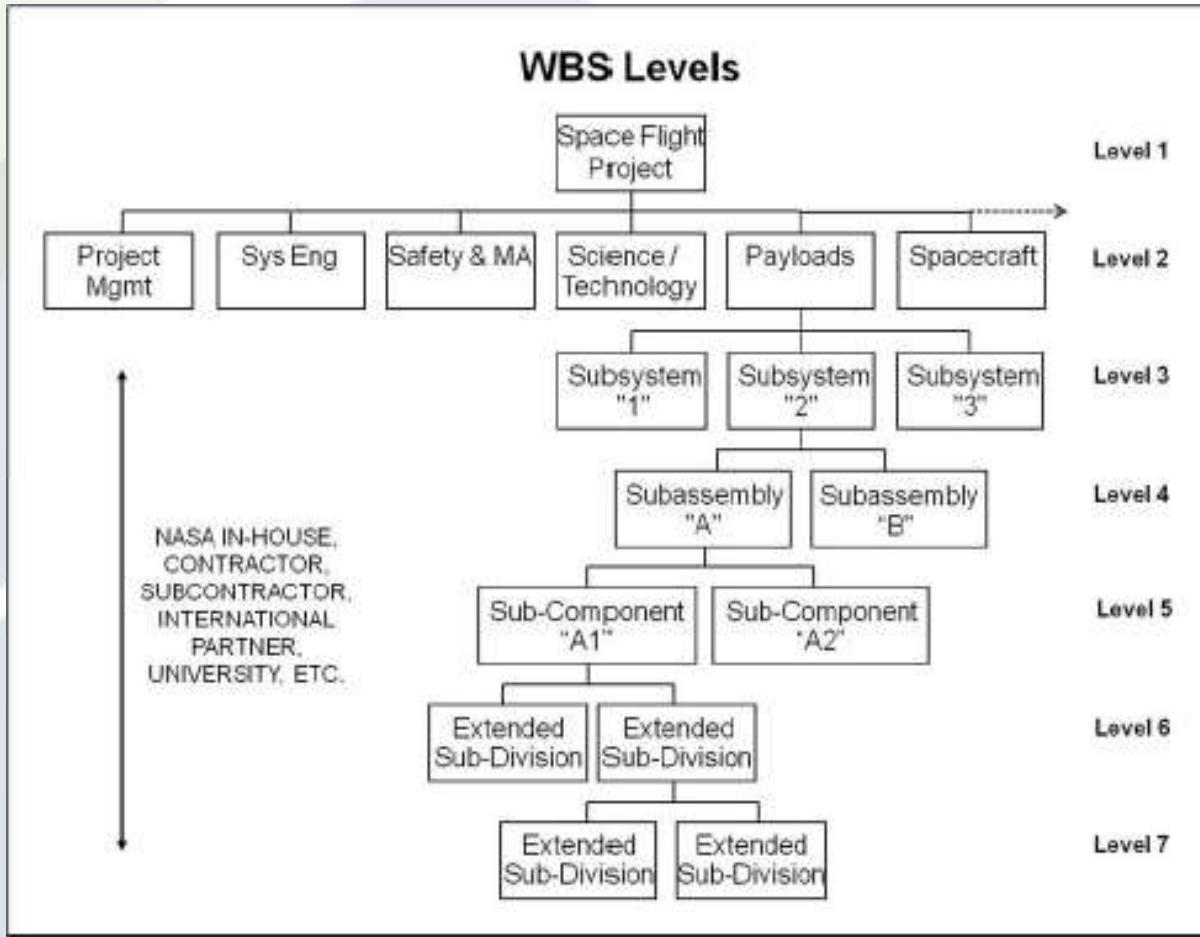
- A task-oriented family tree of activities which organises, defines and graphically displays the total work to be accomplished in order to achieve the final objectives of the project (PMI, from Chandrashekhar et al. 1993)
- The WBS is the cornerstone of a project and provides the basis for technical, cost and schedule control. [DEF(AUST)5664A]





# WBS representation

## Tree structures



Level 1	Level 2	Level 3	Level 4
Project			
	Task 1		
		Sub Task1.1	
			Work Package 1.1.1
			Work Package 1.1.2
			Work Package 1.1.3
			Work Package 1.1.4
		Sub Task1.2	
			Work Package 1.2.1
			Work Package 1.2.2
			Work Package 1.2.3
			Work Package 1.2.4
	Task 2		
		Sub Task2.1	
			Work Package 2.1.1
			Work Package 2.1.2
			Work Package 2.1.3
			Work Package 2.1.4
		Sub Task2.2	
			Work Package 2.2.1
			Work Package 2.2.2
			Work Package 2.2.3
			Work Package 2.2.4
		Sub Task2.3	
			Work Package 2.3.1
			Work Package 2.3.2

## Outlining

# AUS(DEF)5664 Requirement 1



- Integrated – A single top WBS Element covers the total body of work.
  - Distinct – Every WBS Element is a distinct Product or Enabling Service, which is mutually exclusive from other Products and Enabling Services.
  - Children – Every WBS Element has either no children, or multiple children.
  - Descendant – Every child WBS Element has only one parent and is a descendant of the top WBS Element.
  - Necessary – Every child WBS Element is needed to deliver the parent.
  - Sufficient – If all child WBS Elements are complete, their parent is complete.
  - Complete – The complete scope of work is captured in the WBS.
- 
- Rules I have issue with
- 100% Rule (Project Scope)
  - Every WBS Element has either no children, or multiple children.

# Can we fix it?

---

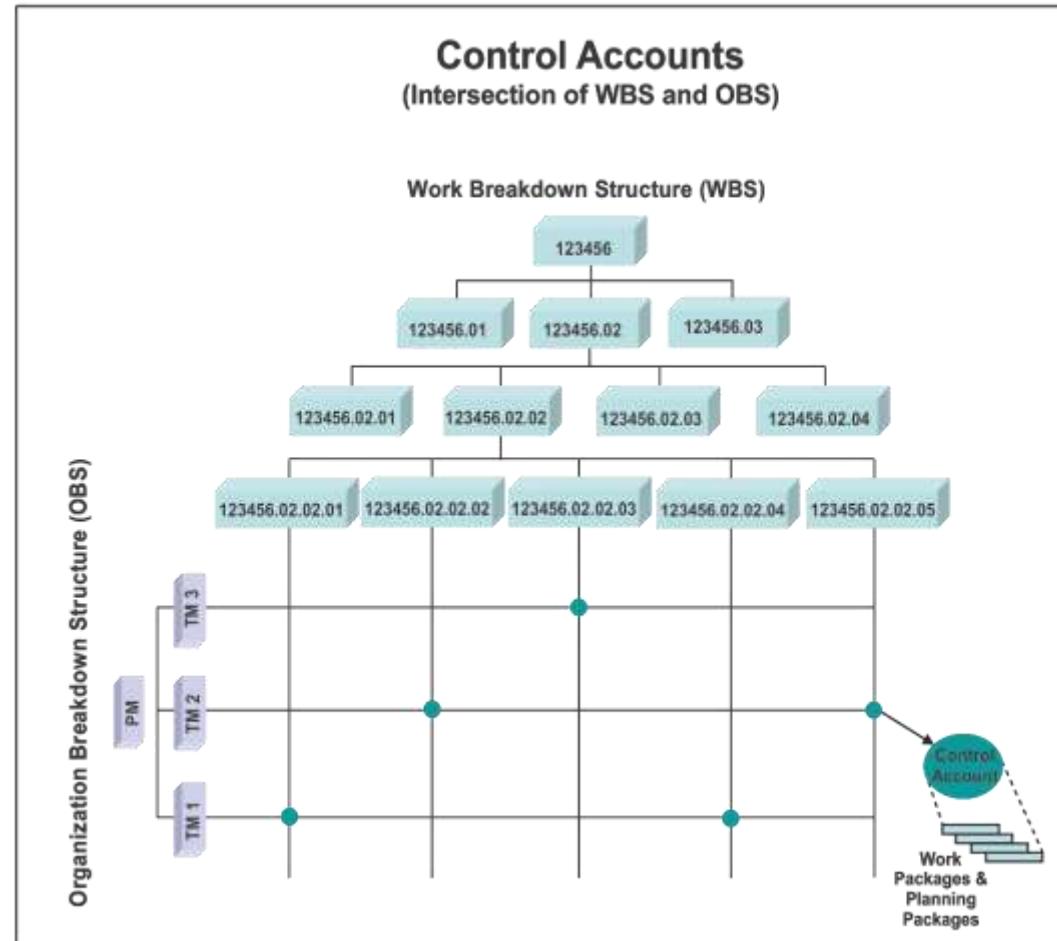


# Can we fix it? Yes we can!

---



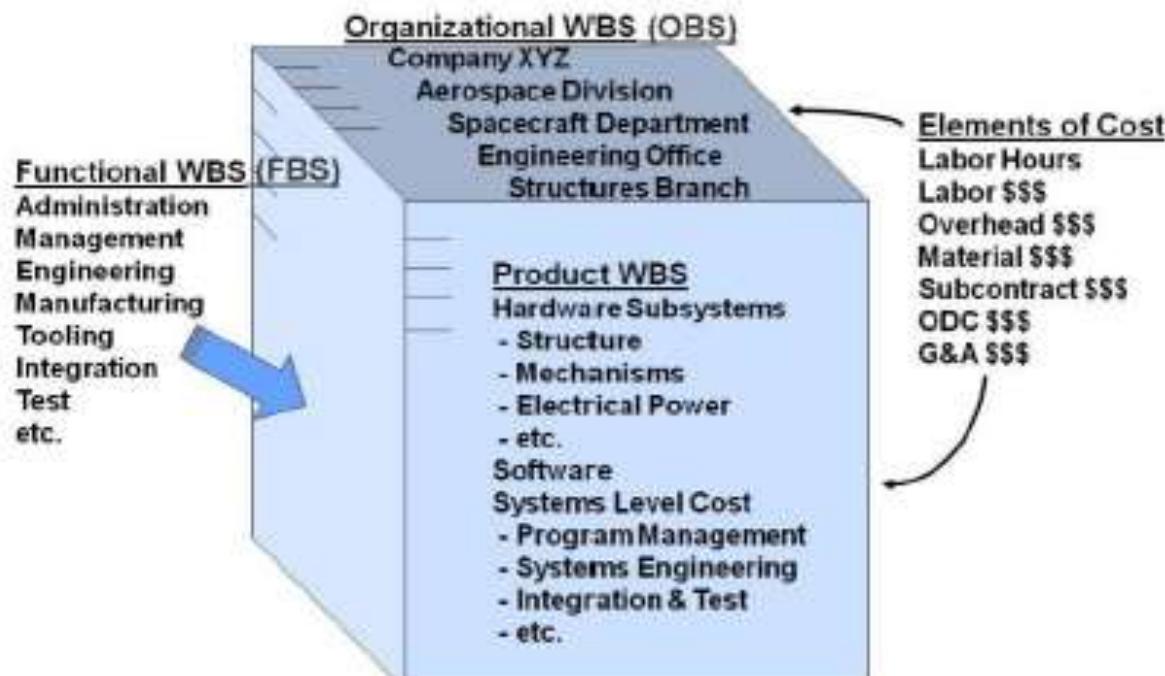
# Relationship to other decomposition structures



- Organisational Breakdown Structure (OBS)
- Bill of Materials (BOM)
- Resource Breakdown Structure (RBS)
- None of these change the demands on the WBS

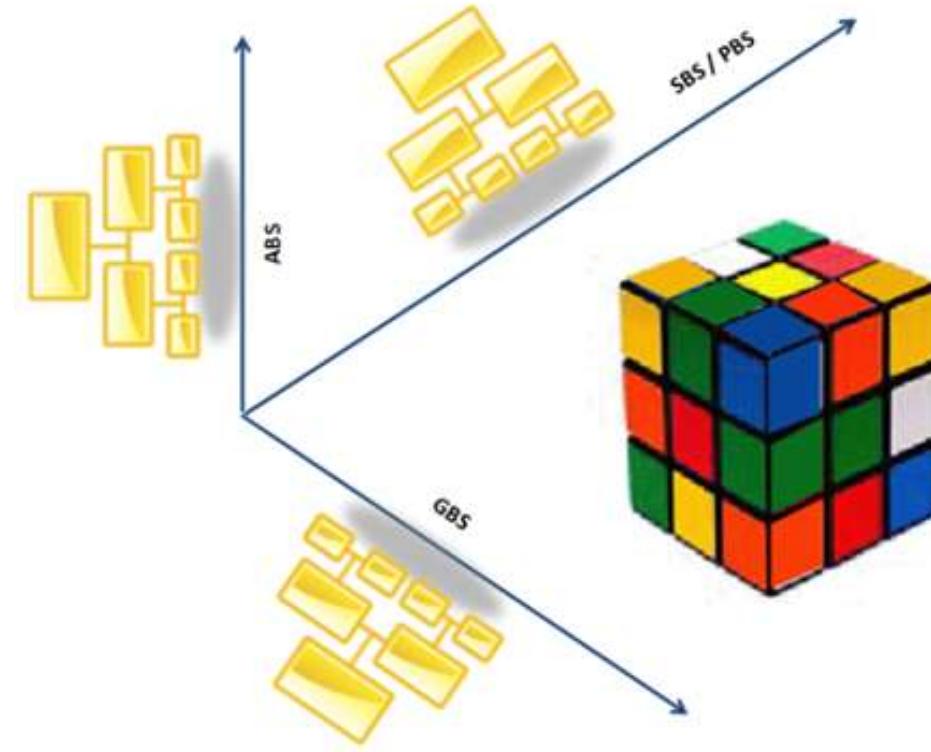
# Multi-dimensional decomposition relationships

NASA



NASA WBS Handbook (2010)

Moine's 3DWBS



Moine (2012)

# Infrastructure project decomposition

## Vertical Infrastructure

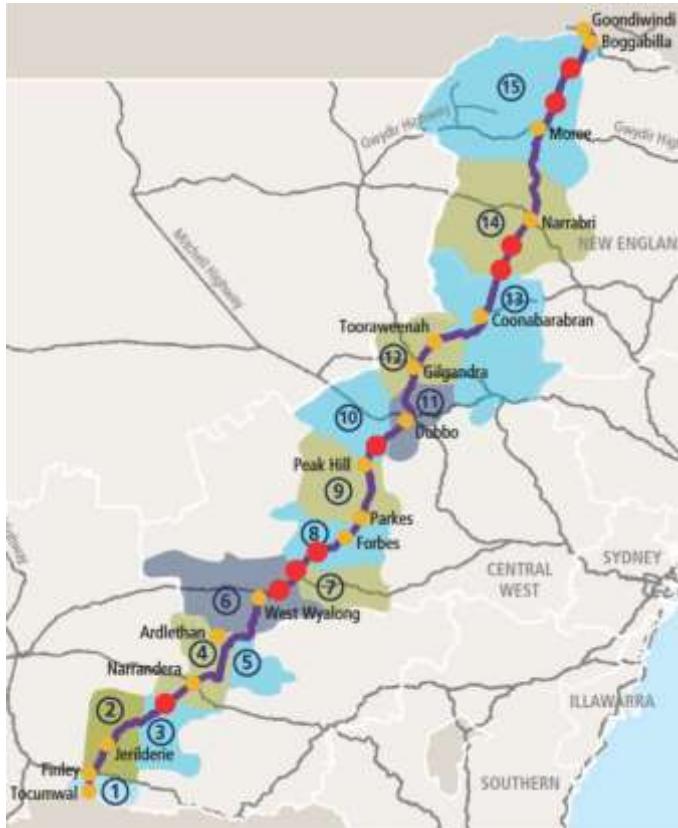


## Horizontal Infrastructure



# Infrastructure project decomposition

## Distributed Infrastructure Assets



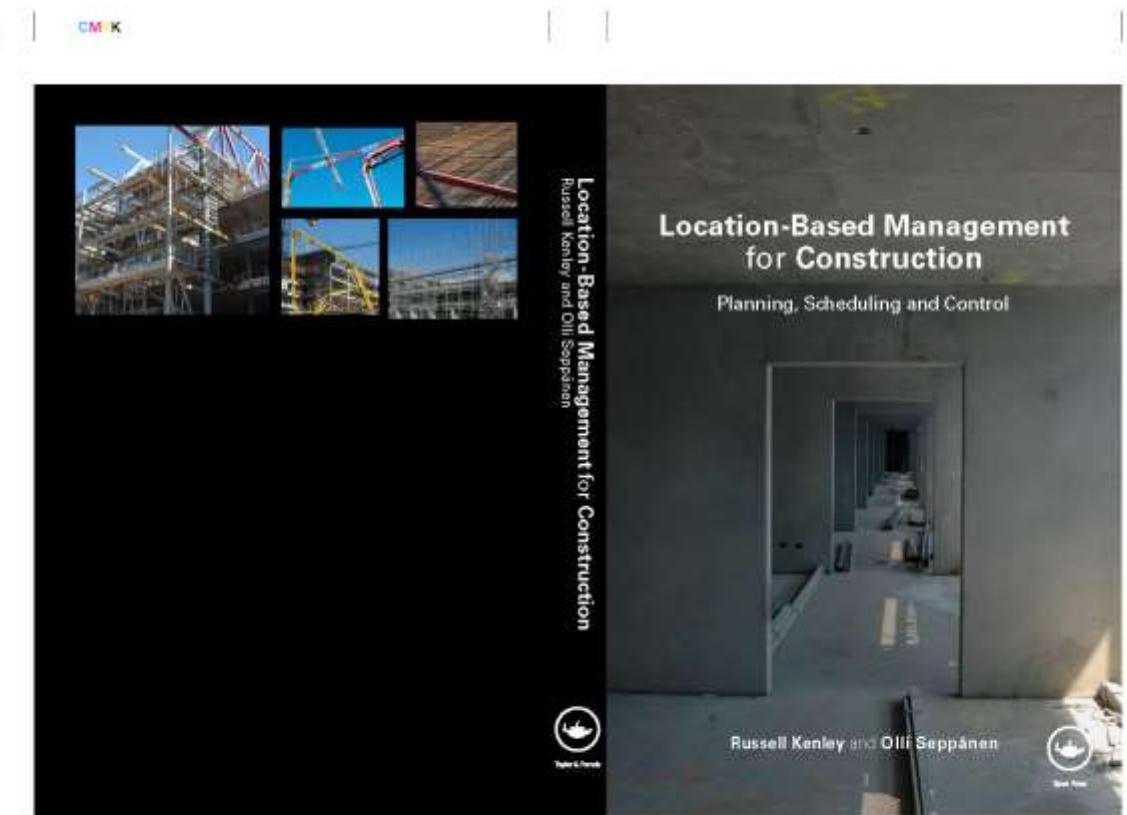
## Distributed Construction/Maintenance



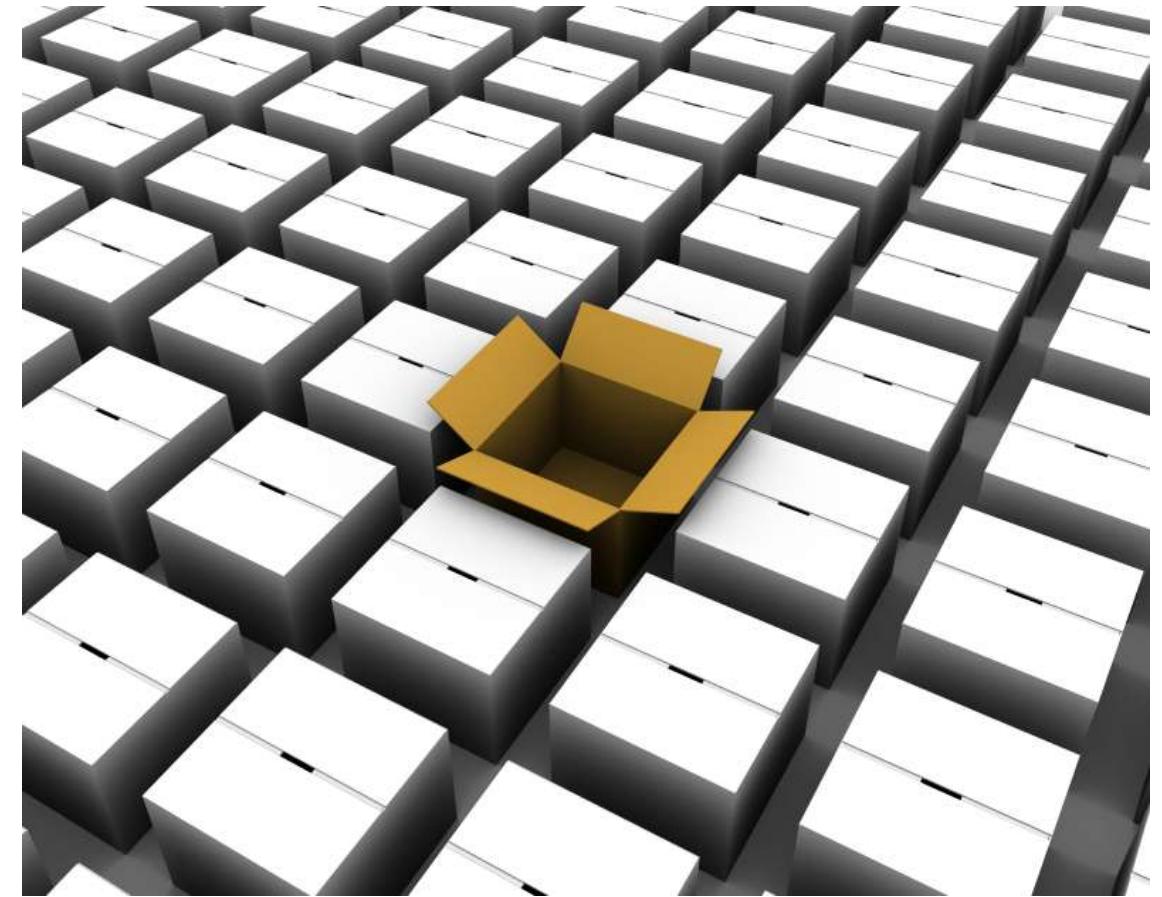


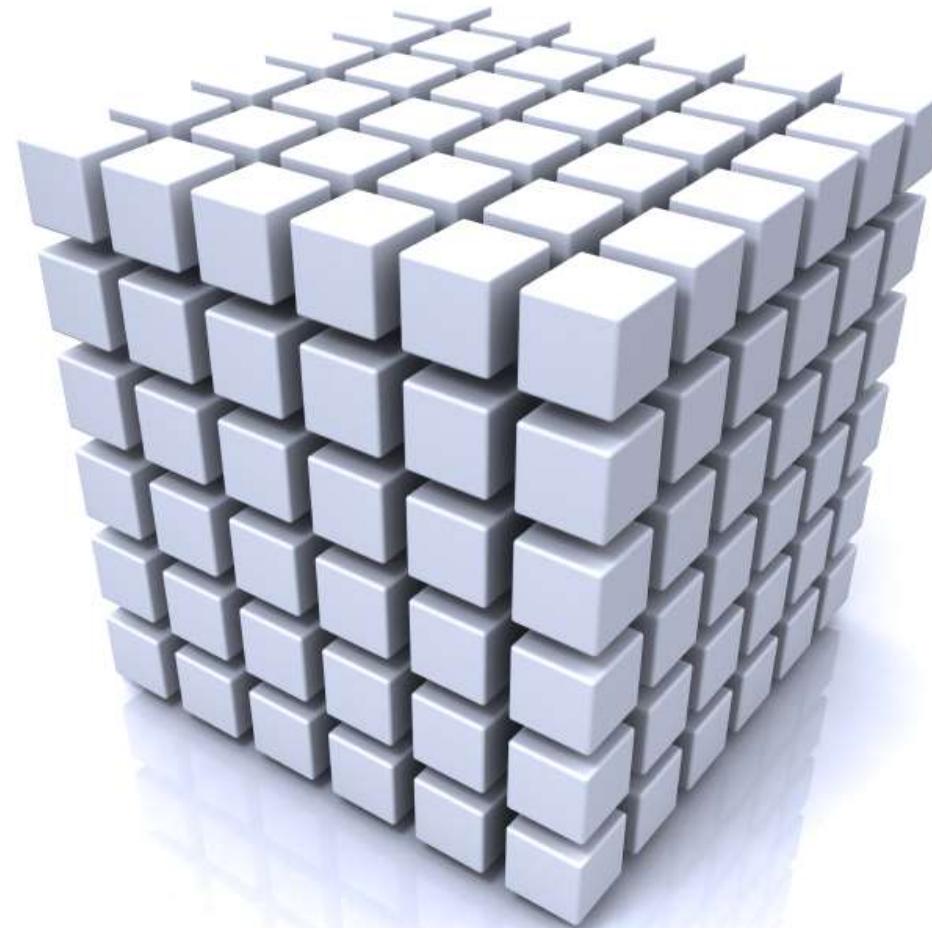
# Location-based management systems

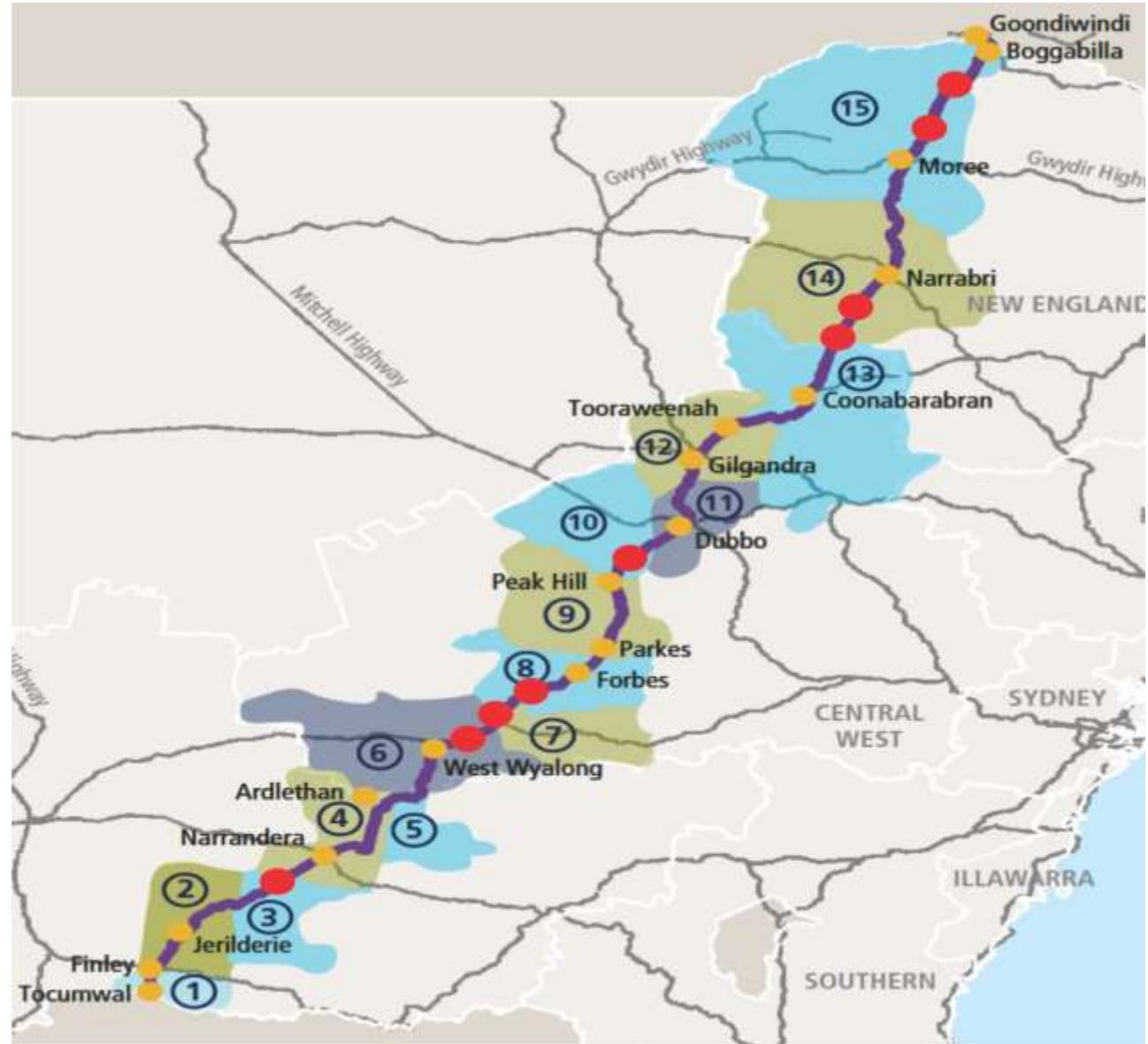
- Managing by location in construction improves production











# Location-based management systems



Analog



Digital





# Location effects on project decomposition

- BO1 RESI. BLDG.PROJECT
- ...
- BO1.4 CONSTRUCTION
- ...
- BO1.4 .3 Super Structure
- BO1.4 .3 .1 Ground Floor Level
- BO1.4 .3 .1 .A Slab Work
- BO1.4 .3 .1 .A .1 Column
- BO1.4 .3 .1 .A .1.1 Rebar
- BO1.4 .3 .1 .A .1.2 Form Work
- BO1.4 .3 .1 .A .1.3 Concreting
- BO1.4 .3 .1 .A .2 Shear Wall
- BO1.4 .3 .1 .A .2.1 Rebar
- BO1.4 .3 .1 .A .2.2 Form Work
- BO1.4 .3 .1 .A .2.3 Concreting
- BO1.4 .3 .1 .A .3 Slab
- BO1.4 .3 .1 .A .3 .1 Form Work
- BO1.4 .3 .1 .A .3 .2 Rebar
- BO1.4 .3 .1 .A .3 .3 MEP Work
- BO1.4 .3 .1 .A .3 .4 Concreting
- BO1.4 .3 .2 First Floor Level
- BO1.4 .3 .2 .A Slab Work
- BO1.4 .3 .2 .A .1 Column
- BO1.4 .3 .2 .A .1 .1 Rebar
- BO1.4 .3 .2 .A .1 .2 Form Work
- BO1.4 .3 .2 .A .1 .3 Concreting
- BO1.4 .3 .2 .A .2 Shear Wall
- BO1.4 .3 .2 .A .2 .1 Rebar
- BO1.4 .3 .2 .A .2 .2 Form Work
- BO1.4 .3 .2 .A .2 .3 Concreting
- BO1.4 .3 .2 .A .3 .1 Slab
- BO1.4 .3 .2 .A .3 .2 Rebar
- BO1.4 .3 .2 .A .3 .3 MEP Work
- BO1.4 .3 .2 .A .3 .4 Concreting
- BO1.4 .3 .3 Second Floor Level
- BO1.4 .3 .3 .A Slab Work
- BO1.4 .3 .3 .A .1 Column
- BO1.4 .3 .3 .A .2 Shear Wall
- BO1.4 .3 .3 .A .3 Slab
- BO1.4 .3 .3 .B Part 2
- BO1.4 .3 .3 .B .1 Column
- BO1.4 .3 .3 .B .2 Shear Wall
- BO1.4 .3 .3 .B .3 Slab
- BO1.4 .3 .4 Third Floor Level
- BO1.4 .3 .4 .A Part 1
- BO1.4 .3 .4 .A .1 Column
- BO1.4 .3 .4 .A .2 Shear Wall
- BO1.4 .3 .4 .A .3 Slab
- BO1.4 .3 .4 .B Part 2
- BO1.4 .3 .4 .B .1 Column
- BO1.4 .3 .4 .B .2 Shear Wall
- BO1.4 .3 .4 .B .3 Slab

- Location has been found to be a key breakdown component of traditional WBS  
(Ibrahim et al., 2009)
- Integrating ‘location’ into [traditional] WBS decomposition necessitates substantial repetition in data and processes  
(Stal-Le Cardinal & Marle, 2006)

# Location-Work Breakdown Matrix

- BO1 RESI. BLDG.PROJECT
- ...
- BO1.4 CONSTRUCTION
- ...
- BO1.4 .3 Super Structure
- **BO1.4 .3 .1 Ground Floor Level**
- BO1.4 .3 .1 .A Slab Work
- BO1.4 .3 .1 .A .1 Column
- BO1.4 .3 .1 .A .1.1 Rebar
- BO1.4 .3 .1 .A .1.2 Form Work
- BO1.4 .3 .1 .A .1.3 Concreting
- BO1.4 .3 .1 .A .2 Shear Wall
- BO1.4 .3 .1 .A .2.1 Rebar
- BO1.4 .3 .1 .A .2.2 Form Work
- BO1.4 .3 .1 .A .2.3 Concreting
- BO1.4 .3 .1 .A .3 Slab
- BO1.4 .3 .1 .A .3 .1 Form Work
- BO1.4 .3 .1 .A .3 .2 Rebar
- BO1.4 .3 .1 .A .3 .3 MEP Work
- BO1.4 .3 .1 .A .3 .4 Concreting
- **BO1.4 .3 .2 First Floor Level**
- BO1.4 .3 .2 .A Slab Work
- BO1.4 .3 .2 .A .1 Column
- BO1.4 .3 .2 .A .1.1 Rebar
- BO1.4 .3 .2 .A .1.2 Form Work
- BO1.4 .3 .2 .A .1.3 Concreting
- BO1.4 .3 .2 .A .2 Shear Wall
- BO1.4 .3 .2 .A .2.1 Rebar
- BO1.4 .3 .2 .A .2.2 Form Work
- BO1.4 .3 .2 .A .2.3 Concreting
- BO1.4 .3 .2 .A .3 .1 Slab
- BO1.4 .3 .2 .A .3 .2 .A .3 .1 Form Work
- BO1.4 .3 .2 .A .3 .2 .A .3 .2 Rebar
- BO1.4 .3 .2 .A .3 .3 .A .3 .1 MEP Work
- BO1.4 .3 .2 .A .3 .4 .A .3 .1 Concreting
- **BO1.4 .3 .3 Second Floor Level**
- BO1.4 .3 .3 .A Slab Work
- BO1.4 .3 .3 .A .1 Column
- BO1.4 .3 .3 .A .2 Shear Wall
- BO1.4 .3 .3 .A .3 Slab
- BO1.4 .3 .3 .B Part 2
- BO1.4 .3 .3 .B .1 Column
- BO1.4 .3 .3 .B .2 Shear Wall
- BO1.4 .3 .3 .B .3 Slab
- **BO1.4 .3 .4 Third Floor Level**
- BO1.4 .3 .4 .A Part 1
- BO1.4 .3 .4 .A .1 Column
- BO1.4 .3 .4 .A .2 Shear Wall
- BO1.4 .3 .4 .A .3 Slab
- BO1.4 .3 .4 .B Part 2
- BO1.4 .3 .4 .B .1 Column
- BO1.4 .3 .4 .B .2 Shear Wall
- BO1.4 .3 .4 .B .3 Slab

The used coding may be mapped as follows:  
**L1 .X1 .X2 .L2 .L3/X3 .X4 .T**

Where:

<b>L1=Building</b>	– coded B01
<b>X1=Construction</b>	– coded 4
<b>X2= Superstructure</b>	– coded 3
<b>L2=Level</b>	– coded 1 to 3
<b>L3=Zone</b>	– coded A to B
<b>X3=Element</b>	– <b>not coded</b> , described
<b>X4=Component</b>	– coded 1 to 3
<b>T=Activity</b>	– coded 1 to 4

The merging of L3 and X3 into a single code greatly increases confusion in interpreting this structure.

# Location-Work Breakdown Matrix

- BO1 RESI. BLDG.PROJECT
- ...
- BO1.4 CONSTRUCTION
- ...
- BO1.4 .3 Super Structure
- BO1.4 .3 .1 Ground Floor Level
- BO1.4 .3 .1 .A Slab Work
- BO1.4 .3 .1 .A .1 Column
- BO1.4 .3 .1 .A .1.1 Rebar
- BO1.4 .3 .1 .A .1.2 Form Work
- BO1.4 .3 .1 .A .1.3 Concreting
- BO1.4 .3 .1 .A .2 Shear Wall
- BO1.4 .3 .1 .A .2.1 Rebar
- BO1.4 .3 .1 .A .2.2 Form Work
- BO1.4 .3 .1 .A .2.3 Concreting
- BO1.4 .3 .1 .A .3 Slab
- BO1.4 .3 .1 .A .3 .1 Form Work
- BO1.4 .3 .1 .A .3 .2 Rebar
- BO1.4 .3 .1 .A .3 .3 MEP Work
- BO1.4 .3 .1 .A .3 .4 Concreting
- BO1.4 .3 .2 First Floor Level
- BO1.4 .3 .2 .A Slab Work
- BO1.4 .3 .2 .A .1 Column
- BO1.4 .3 .2 .A .1.1 Rebar
- BO1.4 .3 .2 .A .1.2 Form Work
- BO1.4 .3 .2 .A .1.3 Concreting
- BO1.4 .3 .2 .A .2 Shear Wall
- BO1.4 .3 .2 .A .2.1 Rebar
- BO1.4 .3 .2 .A .2.2 Form Work
- BO1.4 .3 .2 .A .2.3 Concreting

The result will be a two lists:

- LBS: the location breakdown (the where [L])  
in this case: L1 .L2 .L3
- WBS: the work breakdown (the what [X] and how [T])  
in this case: X1 .X2 .X3 .X4 .X5 .T

With the actual work (.T) belonging at the intersection of the two lists **and thus belonging to both** which is why it requires the matrix to describe all work.

# Location effects on project decomposition

- BO1 RESI. BLDG.PROJECT
  - ...
  - BO1.4 CONSTRUCTION
  - ...
  - BO1.4 .3 Super Structure
  - BO1.4 .3 .1 Ground Floor Level
  - BO1.4 .3 .1 .A Slab Work
  - BO1.4 .3 .1 .A . 1 Column
  - BO1.4 .3 .1 .A . 1.1 Rebar
  - BO1.4 .3 .1 .A . 1.2 Form Work
  - BO1.4 .3 .1 .A . 1.3 Concreting
  - BO1.4 .3 .1 .A . 2 Shear Wall
  - BO1.4 .3 .1 .A . 2 .1 Rebar
  - BO1.4 .3 .1 .A . 2 .2 Form Work
  - BO1.4 .3 .1 .A . 2 .3 Concreting
  - BO1.4 .3 .1 .A . 3 Slab
  - BO1.4 .3 .1 .A . 3 .1 Form Work
  - BO1.4 .3 .1 .A . 3 .2 Rebar
  - BO1.4 .3 .1 .A . 3 .3 MEP Work
  - BO1.4 .3 .1 .A . 3 .4 Concreting
  - BO1.4 .3 .2 First Floor Level
  - BO1.4 .3 .2 .A Slab Work
  - BO1.4 .3 .2 .A . 1 Column
  - BO1.4 .3 .2 .A . 1 .1 Rebar
  - BO1.4 .3 .2 .A . 1 .2 Form Work
  - BO1.4 .3 .2 .A . 1 .3 Concreting
  - BO1.4 .3 .2 .A . 2 Shear Wall
  - BO1.4 .3 .2 .A . 2 .1 Rebar
  - BO1.4 .3 .2 .A . 2 .2 Form Work
  - BO1.4 .3 .2 .A . 2 .3 Concreting
  - BO1.4 .3 .2 .A . 3 Slab
  - BO1.4 .3 .2 .A . 3 .1 Form Work
  - BO1.4 .3 .2 .A . 3 .2 Rebar
  - BO1.4 .3 .2 .A . 3 .3 MEP Work
  - BO1.4 .3 .2 .A . 3 .4 Concreting
  - BO1.4 .3 .3 Second Floor Level
  - BO1.4 .3 .3 .A Slab Work
  - BO1.4 .3 .3 .A . 1 Column
  - BO1.4 .3 .3 .A . 2 Shear Wall
  - BO1.4 .3 .3 .A . 3 Slab
  - BO1.4 .3 .3 .B Part 2
  - BO1.4 .3 .3 .B . 1 Column
  - BO1.4 .3 .3 .B . 2 Shear Wall
  - BO1.4 .3 .3 .B . 3 Slab
  - BO1.4 .3 .4 Third Floor Level
  - BO1.4 .3 .4 .A Part 1
  - BO1.4 .3 .4 .A . 1 Column
  - BO1.4 .3 .4 .A . 2 Shear Wall
  - BO1.4 .3 .4 .A . 3 Slab
  - BO1.4 .3 .4 .B Part 2
  - BO1.4 .3 .4 .B . 1 Column
  - BO1.4 .3 .4 .B . 2 Shear Wall
  - BO1.4 .3 .4 .B . 3 Slab

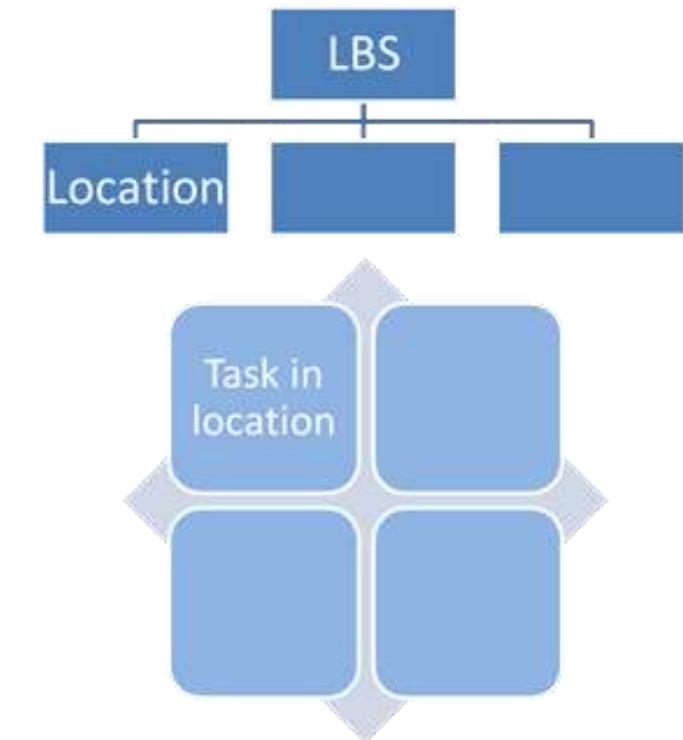
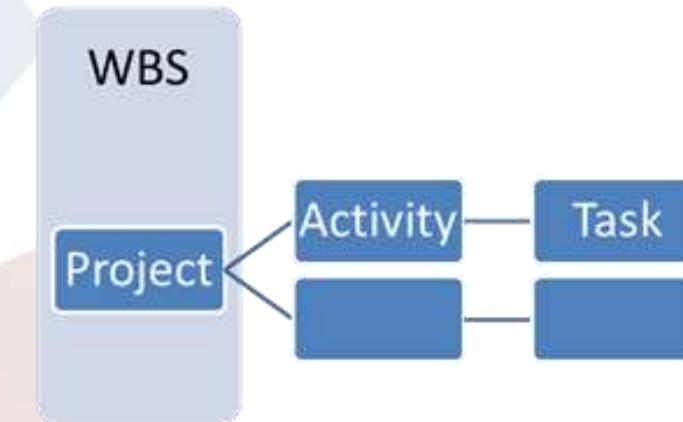
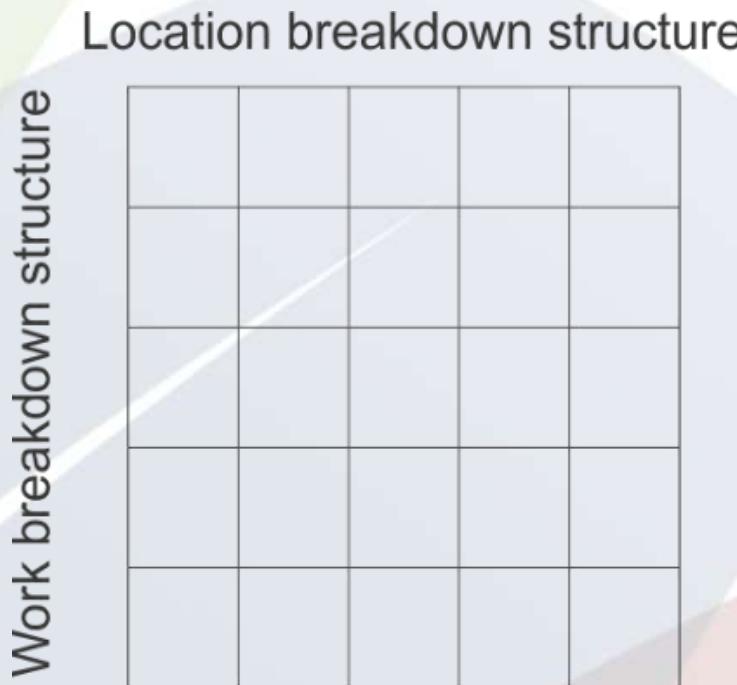
## LBS (L1 .L2 .L3)

- BO1 RESI. BLDG.PROJECT
  - BO1.1 Ground Floor Level
  - B01.1.A Zone A
  - BO1.2 First Floor Level
  - B01.2.A Zone A
  - BO1.3 Second Floor Level
  - B01.3.A Zone A
  - B01.3.B Zone B
  - BO1.4 Third Floor Level
  - B01.4.A Zone A
  - B01.4.B Zone B

## **WBS (X1 .X2 .X3 .X4 .X5 .T)**

- 4 CONSTRUCTION
  - 4 .3 Super Structure
  - 4 .3 .1 Slab Work
  - 4 .3 .1 .1 Column
  - 4 .3 .1 .1.1 Column Rebar
  - 4 .3 .1 .1.2 Column Form Work
  - 4 .3 .1 .1.3 Column Concreting
  - 4 .3 .1 .2 Shear Wall
  - 4 .3 .1 .2 .1 S'Wall Rebar
  - 4 .3 .1 .2 .2 S'Wall Form Work
  - 4 .3 .1 .2 .3 S'Wall Concreting
  - 4 .3 .1 .3 Slab
  - 4 .3 .1 .3 .1 Slab Form Work
  - 4 .3 .1 .3 .2 Slab Rebar
  - 4 .3 .1 .3 .3 Slab MEP Work
  - 4 .3 .1 .3 .4 Slab Concreting

# Location-Work Breakdown Matrix



# Location-Work Breakdown Matrix

- BO1 RESI. BLDG.PROJECT
  - ...
  - BO1.4 CONSTRUCTION
  - ...
  - BO1.4 .3 Super Structure
  - BO1.4 .3 .1 Ground Floor Level
  - BO1.4 .3 .1 .A Slab Work
  - BO1.4 .3 .1 .A .1 Column
  - BO1.4 .3 .1 .A .1.1 Rebar
  - BO1.4 .3 .1 .A .1.2 Form Work
  - BO1.4 .3 .1 .A .1.3 Concreting
  - BO1.4 .3 .1 .A .2 Shear Wall
  - BO1.4 .3 .1 .A .2 .1 Rebar
  - BO1.4 .3 .1 .A .2 .2 Form Work
  - BO1.4 .3 .1 .A .2 .3 Concreting
  - BO1.4 .3 .1 .A .3 Slab
  - BO1.4 .3 .1 .A .3 .1 Form Work
  - BO1.4 .3 .1 .A .3 .2 Rebar
  - BO1.4 .3 .1 .A .3 .3 MEP Work
  - BO1.4 .3 .1 .A .3 .4 Concreting
  - BO1.4 .3 .2 First Floor Level
  - BO1.4 .3 .2 .A Slab Work
  - BO1.4 .3 .2 .A .1 Column
  - BO1.4 .3 .2 .A .1 .1 Rebar
  - BO1.4 .3 .2 .A .1 .2 Form Work
  - BO1.4 .3 .2 .A .1 .3 Concreting
  - BO1.4 .3 .2 .A .2 Shear Wall
  - BO1.4 .3 .2 .A .2 .1 Rebar
  - BO1.4 .3 .2 .A .2 .2 Form Work
  - BO1.4 .3 .2 .A .2 .3 Concreting

## Work-Location Breakdown Matrix

## **Work Breakdown Structure**

4 CONSTRUCTION

### 4 .3 Super Structure

## 1 Slab Work

#### 4.3.1.1 Column Rebar

#### **4.3.1.1 Column Rebar**

#### 4.3.1.2 Shear Wall

#### 4.3.1.2.1 S'Wall Rebar

#### **4.3.1.2 S'Wall Form Work**

#### 4.3.1.2

### 1.1.3 Slab

#### 4.3.1.3.1 Slab Form Work

#### 4.3.1.3.2 Slab Rebar

#### **4.3.1.3.3 Slab MEP Work**

# Location-Work Breakdown Matrix

- BO1 RESI. BLDG.PROJECT
- ...
- BO1.4 CONSTRUCTION
- ...
- BO1.4 .3 Super Structure
- BO1.4 .3 .1 Ground Floor Level
- BO1.4 .3 .1 .A Slab Work
- BO1.4 .3 .1 .A .1 Column
- **BO1.4 .3 .1 .A .1.1 Rebar**
- BO1.4 .3 .1 .A .1.2 Form Work
- BO1.4 .3 .1 .A .1.3 Concreting
- BO1.4 .3 .1 .A .2 Shear Wall
- BO1.4 .3 .1 .A .2.1 Rebar
- BO1.4 .3 .1 .A .2.2 Form Work
- BO1.4 .3 .1 .A .2.3 Concreting
- BO1.4 .3 .1 .A .3 Slab
- BO1.4 .3 .1 .A .3.1 Form Work
- BO1.4 .3 .1 .A .3.2 Rebar
- BO1.4 .3 .1 .A .3.3 MEP Work
- BO1.4 .3 .1 .A .3.4 Concreting
- BO1.4 .3 .2 First Floor Level
- BO1.4 .3 .2 .A Slab Work
- BO1.4 .3 .2 .A .1 Column
- **BO1.4 .3 .2 .A .1.1 Rebar**
- BO1.4 .3 .2 .A .1.2 Form Work
- BO1.4 .3 .2 .A .1.3 Concreting
- BO1.4 .3 .2 .A .2 Shear Wall
- BO1.4 .3 .2 .A .2.1 Rebar
- BO1.4 .3 .2 .A .2.2 Form Work
- BO1.4 .3 .2 .A .2.3 Concreting

## Work-Location Breakdown Matrix

Location Breakdown Structure	Task										
	BO1 RESI. BLDG.PROJECT	BO1.1 Ground Floor Level	BO1.1.A Zone A	BO1.2 First Floor Level	BO1.2.A Zone A	BO1.3 Second Floor Level	BO1.3.A Zone A	BO1.3.B Zone B	BO1.4 Third Floor Level	BO1.4.A Zone A	BO1.4.B Zone B
BO1.4 .3 Super Structure											
BO1.4 .3 .1 Ground Floor Level											
BO1.4 .3 .1 .A Slab Work											
BO1.4 .3 .1 .A .1 Column											
<b>BO1.4 .3 .1 .A .1.1 Rebar</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BO1.4 .3 .1 .A .1.2 Form Work											
BO1.4 .3 .1 .A .1.3 Concreting											
BO1.4 .3 .1 .A .2 Shear Wall											
BO1.4 .3 .1 .A .2.1 Rebar											
BO1.4 .3 .1 .A .2.2 Form Work											
BO1.4 .3 .1 .A .2.3 Concreting											
BO1.4 .3 .1 .A .3 Slab											
BO1.4 .3 .1 .A .3.1 Form Work											
BO1.4 .3 .1 .A .3.2 Rebar											
BO1.4 .3 .1 .A .3.3 MEP Work											
BO1.4 .3 .1 .A .3.4 Concreting											
BO1.4 .3 .2 First Floor Level											
BO1.4 .3 .2 .A Slab Work											
BO1.4 .3 .2 .A .1 Column											
<b>BO1.4 .3 .2 .A .1.1 Rebar</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BO1.4 .3 .2 .A .1.2 Form Work											
BO1.4 .3 .2 .A .1.3 Concreting											
BO1.4 .3 .2 .A .2 Shear Wall											
BO1.4 .3 .2 .A .2.1 Rebar											
BO1.4 .3 .2 .A .2.2 Form Work											
BO1.4 .3 .2 .A .2.3 Concreting											
BO1.4 .3 .3 Second Floor Level											
BO1.4 .3 .3 .A Slab Work											
BO1.4 .3 .3 .A .1 Column											
<b>BO1.4 .3 .3 .A .1.1 Rebar</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BO1.4 .3 .3 .A .2 Shear Wall											
BO1.4 .3 .3 .A .3 Slab											
BO1.4 .3 .3 .B Part 2											
BO1.4 .3 .3 .B .1 Column											
<b>BO1.4 .3 .3 .B .1.1 Rebar</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BO1.4 .3 .3 .B .2 Shear Wall											
BO1.4 .3 .3 .B .3 Slab											
BO1.4 .3 .4 Third Floor Level											
BO1.4 .3 .4 .A Part 1											
<b>BO1.4 .3 .4 .A .1 Column</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BO1.4 .3 .4 .A .2 Shear Wall											
BO1.4 .3 .4 .A .3 Slab											
BO1.4 .3 .4 .B Part 2											
BO1.4 .3 .4 .B .1 Column											
<b>BO1.4 .3 .4 .B .1.1 Rebar</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BO1.4 .3 .4 .B .2 Shear Wall											
BO1.4 .3 .4 .B .3 Slab											

## Work Breakdown Structure

### 4 CONSTRUCTION

#### 4 .3 Super Structure

##### 4 .3 .1 Slab Work

###### 4 .3 .1 .1 Column

4 .3 .1 .1 .1 Column Rebar

4 .3 .1 .1 .2 Column Form Work

4 .3 .1 .1 .3 Column Concreting

###### 4 .3 .1 .2 Shear Wall

4 .3 .1 .2 .1 S'Wall Rebar

4 .3 .1 .2 .2 S'Wall Form Work

4 .3 .1 .2 .3 S'Wall Concreting

###### 4 .3 .1 .3 Slab

4 .3 .1 .3 .1 Slab Form Work

4 .3 .1 .3 .2 Slab Rebar

4 .3 .1 .3 .3 Slab MEP Work

4 .3 .1 .3 .4 Slab Concreting

# Location-Work Breakdown Matrix

- BO1 RESI. BLDG.PROJECT
- ...
- BO1.4 CONSTRUCTION
- ...
- BO1.4 .3 Super Structure
- BO1.4 .3 .1 Ground Floor Level
- BO1.4 .3 .1 .A Slab Work
- BO1.4 .3 .1 .A .1 Column
- BO1.4 .3 .1 .A .1.1 Rebar
- BO1.4 .3 .1 .A .1.2 Form Work
- BO1.4 .3 .1 .A .1.3 Concreting
- BO1.4 .3 .1 .A .2 Shear Wall
- BO1.4 .3 .1 .A .2.1 Rebar
- BO1.4 .3 .1 .A .2.2 Form Work
- BO1.4 .3 .1 .A .2.3 Concreting
- BO1.4 .3 .1 .A .3 Slab
- BO1.4 .3 .1 .A .3 .1 Form Work
- BO1.4 .3 .1 .A .3 .2 Rebar
- BO1.4 .3 .1 .A .3 .3 MEP Work
- BO1.4 .3 .1 .A .3 .4 Concreting
- BO1.4 .3 .2 First Floor Level
- BO1.4 .3 .2 .A Slab Work
- BO1.4 .3 .2 .A .1 Column
- BO1.4 .3 .2 .A .1 .1 Rebar
- BO1.4 .3 .2 .A .1 .2 Form Work
- BO1.4 .3 .2 .A .1 .3 Concreting
- BO1.4 .3 .2 .A .2 Shear Wall
- BO1.4 .3 .2 .A .2.1 Rebar
- BO1.4 .3 .2 .A .2.2 Form Work
- BO1.4 .3 .2 .A .2.3 Concreting

**Work-Location Breakdown Matrix**

Location Breakdown Structure	BO1 RESI. BLDG.PROJECT							
	BO1.1 Ground Floor Level	BO1.1.A Zone A	BO1.2 First Floor Level	BO1.2.A Zone A	BO1.3 Second Floor Level	BO1.3.A Zone A	BO1.3.B Zone B	BO1.4 Third Floor Level
4 CONSTRUCTION								
4 .3 Super Structure								
4 .3 .1 Slab Work								
4 .3 .1 .1 Column								
4 .3 .1 .1 .1 Column Rebar	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .1 .2 Column Form Work	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .1 .3 Column Concreting	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 Shear Wall								
4 .3 .1 .2 .1 S'Wall Rebar	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 .2 S'Wall Form Work	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 .3 S'Wall Concreting	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 Slab								
4 .3 .1 .3 .1 Slab Form Work	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .2 Slab Rebar	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .3 Slab MEP Work	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .4 Slab Concreting	✓	✓	✓	✓	✓	✓	✓	✓

# Location-Work Breakdown Matrix

Work-Location Breakdown Matrix

Work Breakdown Structure		Location Breakdown Structure									
		BO1 RESI. BLDG.PROJECT									
		BO1.1 Ground Floor Level		BO1.2 First Floor Level		BO1.3 Second Floor Level		BO1.4 Third Floor Level		BO1.5 Zone A	
		BO1.1.A Zone A	BO1.1.B Zone B	BO1.2.A Zone A	BO1.2.B Zone B	BO1.3.A Zone A	BO1.3.B Zone B	BO1.4.A Zone A	BO1.4.B Zone B	BO1.5.A Zone A	BO1.5.B Zone B
4 CONSTRUCTION		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 Super Structure		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 Slab Work		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .1 Column		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .1.1 Column Rebar		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .1.2 Column Form Work		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .1.3 Column Concreting		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 Shear Wall		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 .1 S'Wall Rebar		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 .2 S'Wall Form Work		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .2 .3 S'Wall Concreting		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 Slab		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .1 Slab Form Work		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .2 Slab Rebar		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .3 Slab MEP Work		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 .3 .1 .3 .4 Slab Concreting		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

- This is actually a representation with work (T) sorted by product breakdown (PBS).
- The matrix makes sorted by either LBS or PBS simple.

# Work Breakdown Matrix

Work-Location Breakdown Matrix

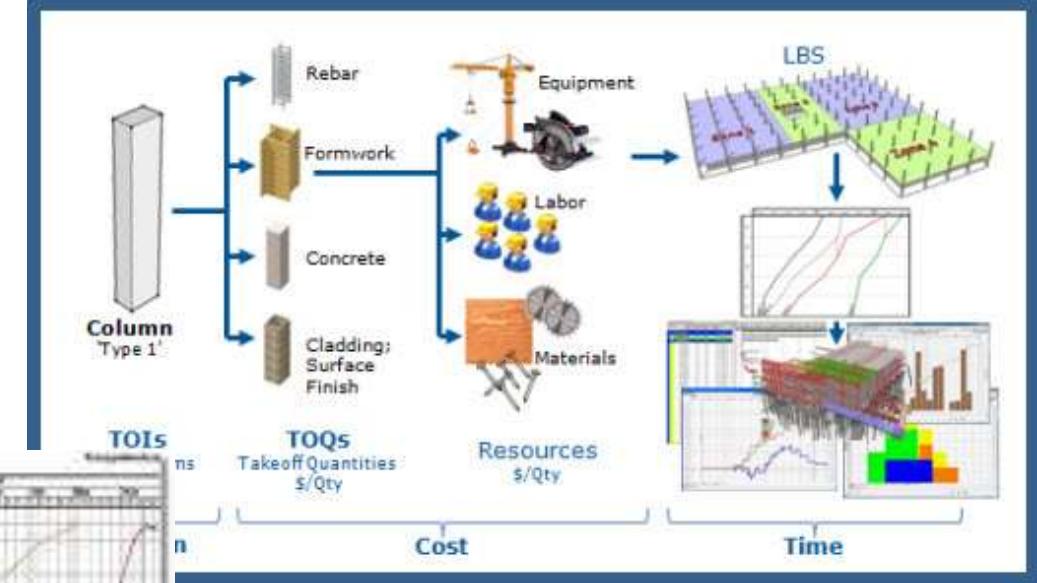
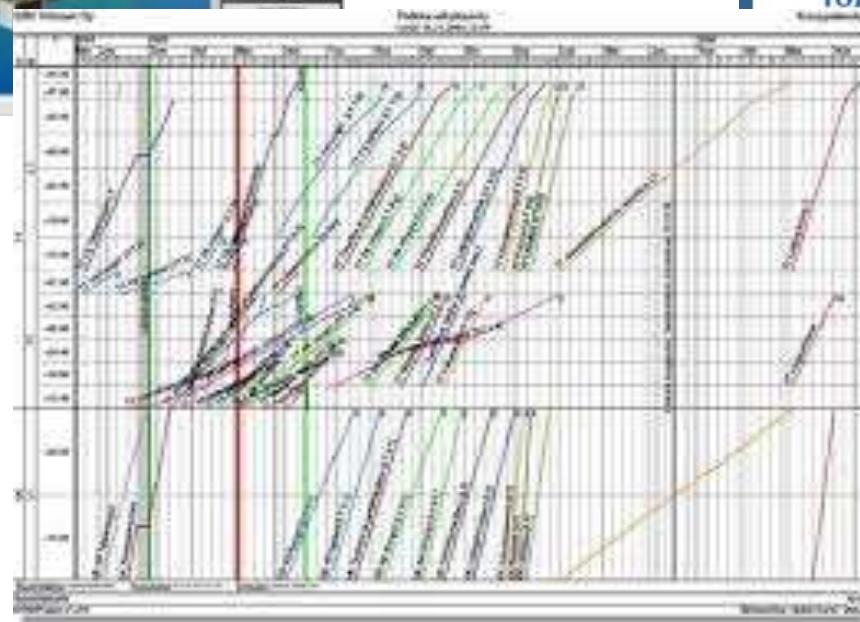
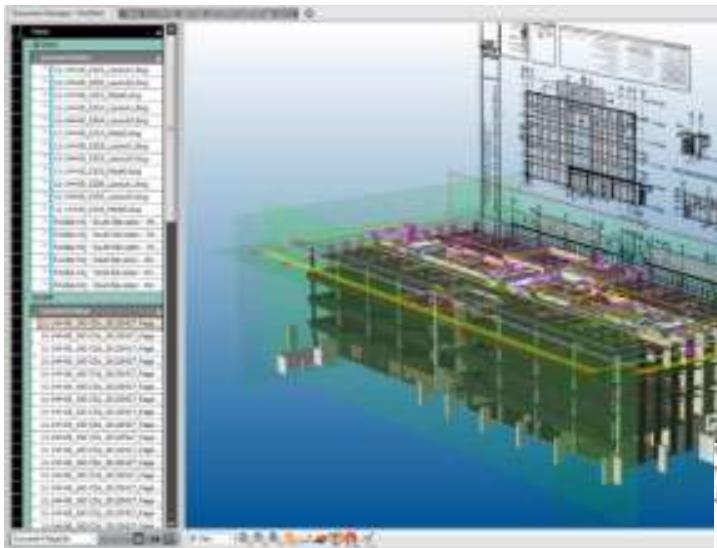
Work Breakdown Structure		Location Breakdown Structure				
		BO1 RESI. BLDG.PROJECT				
		BO1.1 Ground Floor Level				
		B01.1.A Zone A				
		BO1.2 First Floor Level				
		B01.2.A Zone A				
		BO1.3 Second Floor Level				
		B01.3.A Zone A				
		B01.3.B Zone B				
		BO1.4 Third Floor Level				
		B01.4.A Zone A				
		B01.4.B Zone B				
4 CONSTRUCTION						
4 .3 Super Structure						
4 .3 .1 Slab Work						
4 .3 .1 .1 Column						
4 .3 .1 .1 .1 Column Rebar		✓	✓	✓	✓	✓
4 .3 .1 .1 .2 Column Form Work		✓	✓	✓	✓	✓
4 .3 .1 .1 .3 Column Concreting		✓	✓	✓	✓	✓
4 .3 .1 .2 Shear Wall						
4 .3 .1 .2 .1 S'Wall Rebar		✓	✓	✓	✓	✓
4 .3 .1 .2 .2 S'Wall Form Work		✓	✓	✓	✓	✓
4 .3 .1 .2 .3 S'Wall Concreting		✓	✓	✓	✓	✓
4 .3 .1 .3 Slab						
4 .3 .1 .3 .1 Slab Form Work		✓	✓	✓	✓	✓
4 .3 .1 .3 .2 Slab Rebar		✓	✓	✓	✓	✓
4 .3 .1 .3 .3 Slab MEP Work		✓	✓	✓	✓	✓
4 .3 .1 .3 .4 Slab Concreting		✓	✓	✓	✓	✓

- Should the axis actually be
  - Product Breakdown (X)
  - Location Breakdown (L)
- And should the matrix be:
  - Work Breakdown Matrix

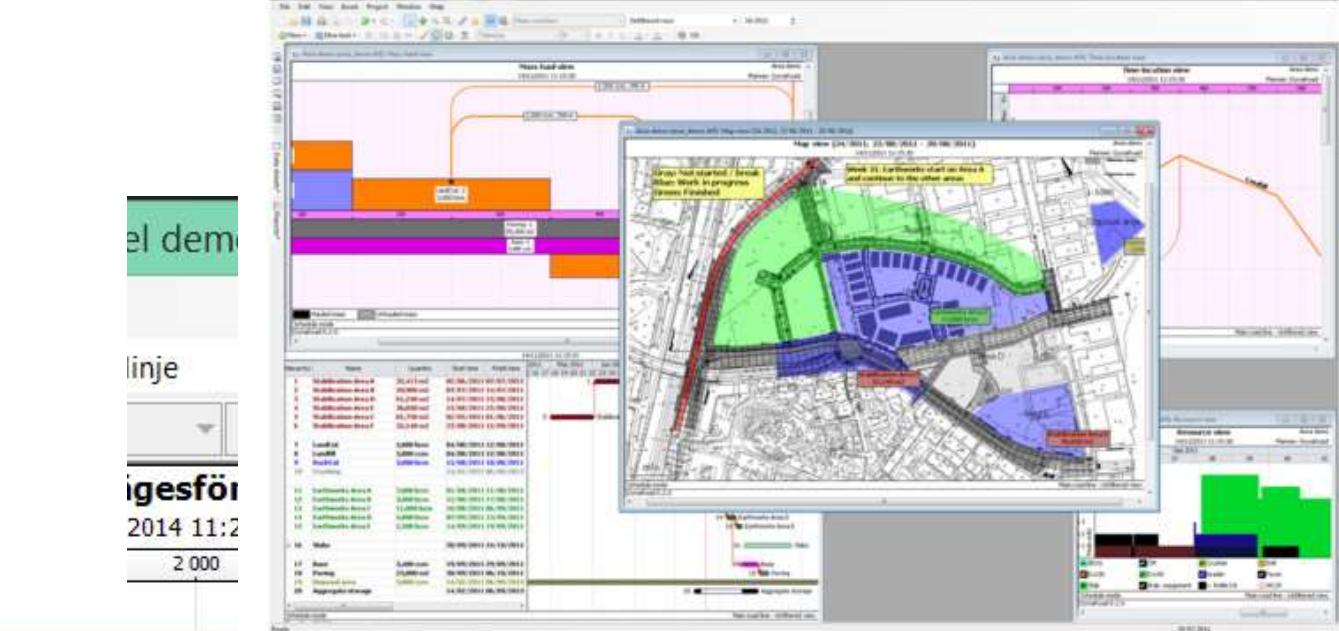
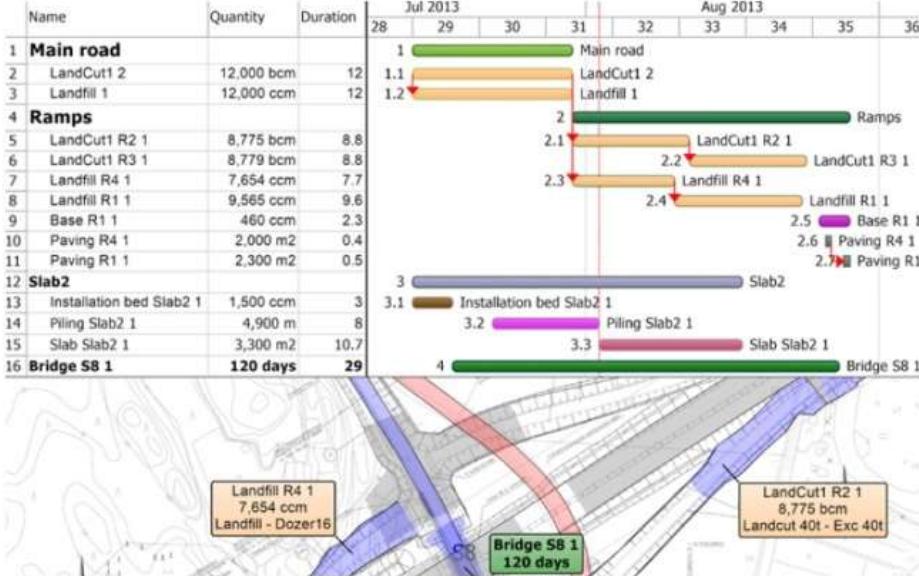




- Examples: Trimble (4.475B company): Vico Office



- Examples: TopCon (1.56B company): DynaRoad

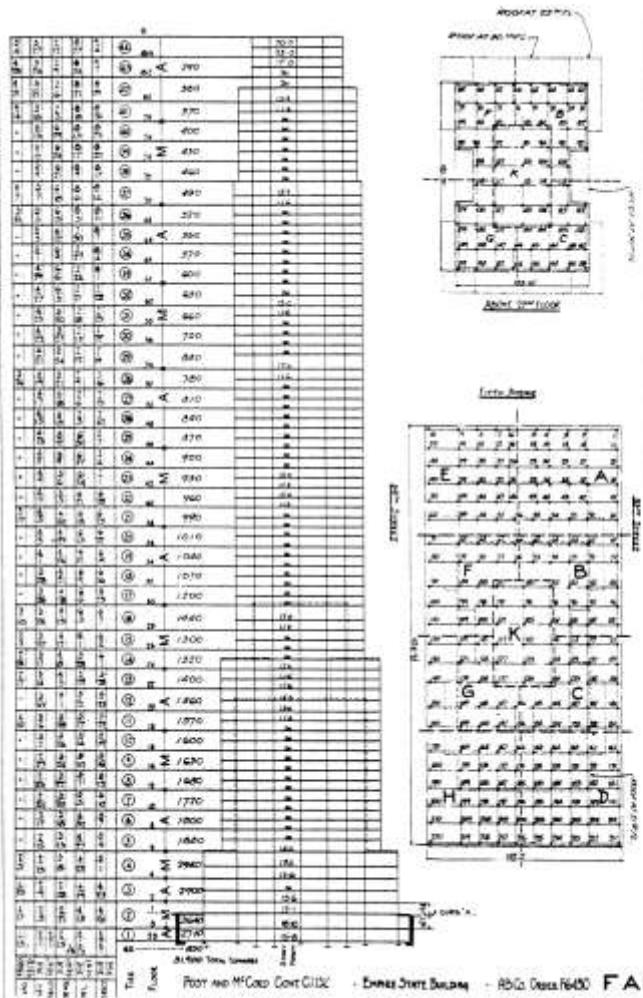


# Empire State Building: LBMS



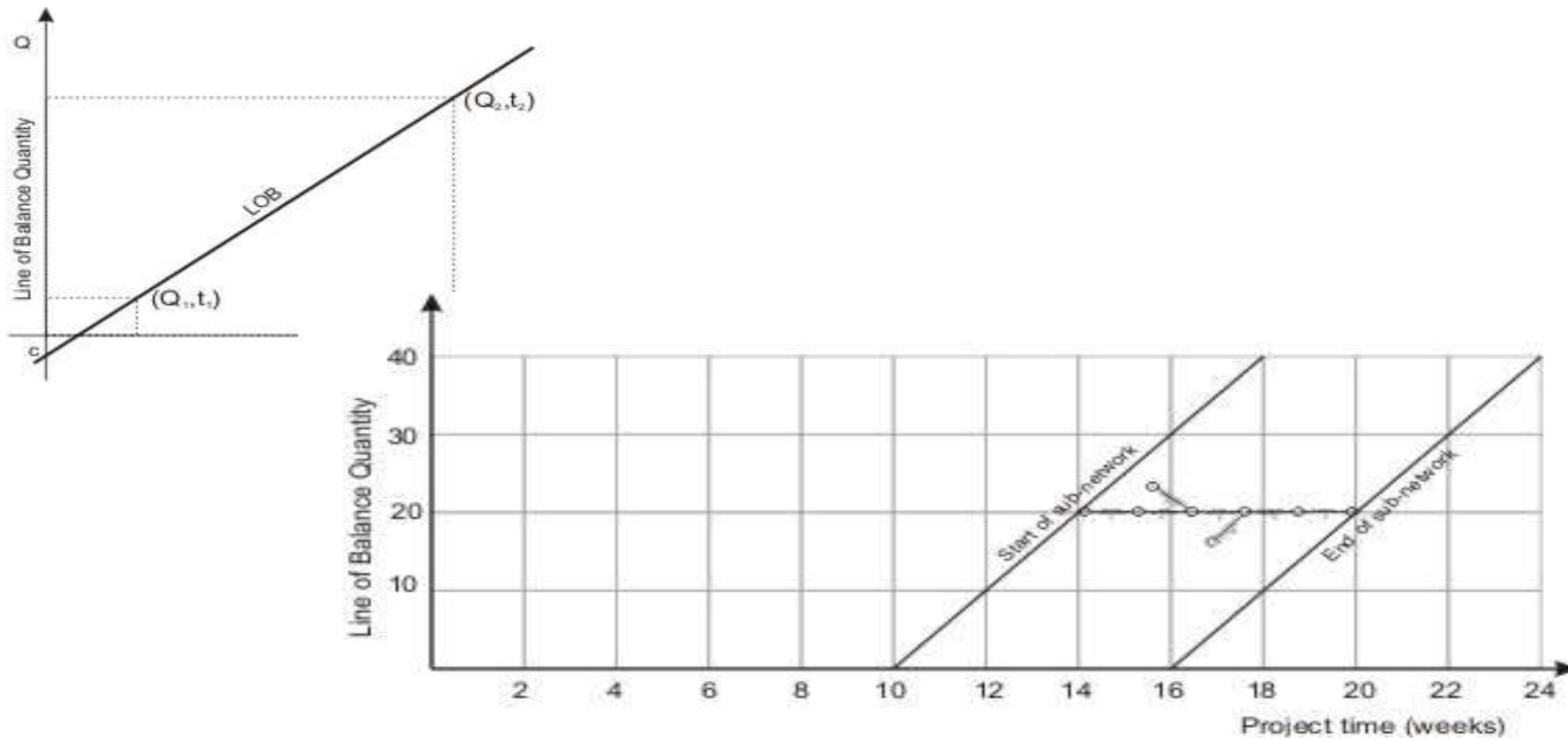
- A 102 level building,
  - sketch designs to opening for business in 18 months;
  - achieving (aligned) floor cycles of one floor per day;
  - structure completed in 4.5 months.
- The production was run like an assembly line
  - continuous and aligned production
- Emphasis on controlling the work.
  - First, actual quantities placed in locations were monitored daily.
  - Second, the work crews were checked to ensure they were working in the correct location three times per day.

# Empire State Building: LBMS

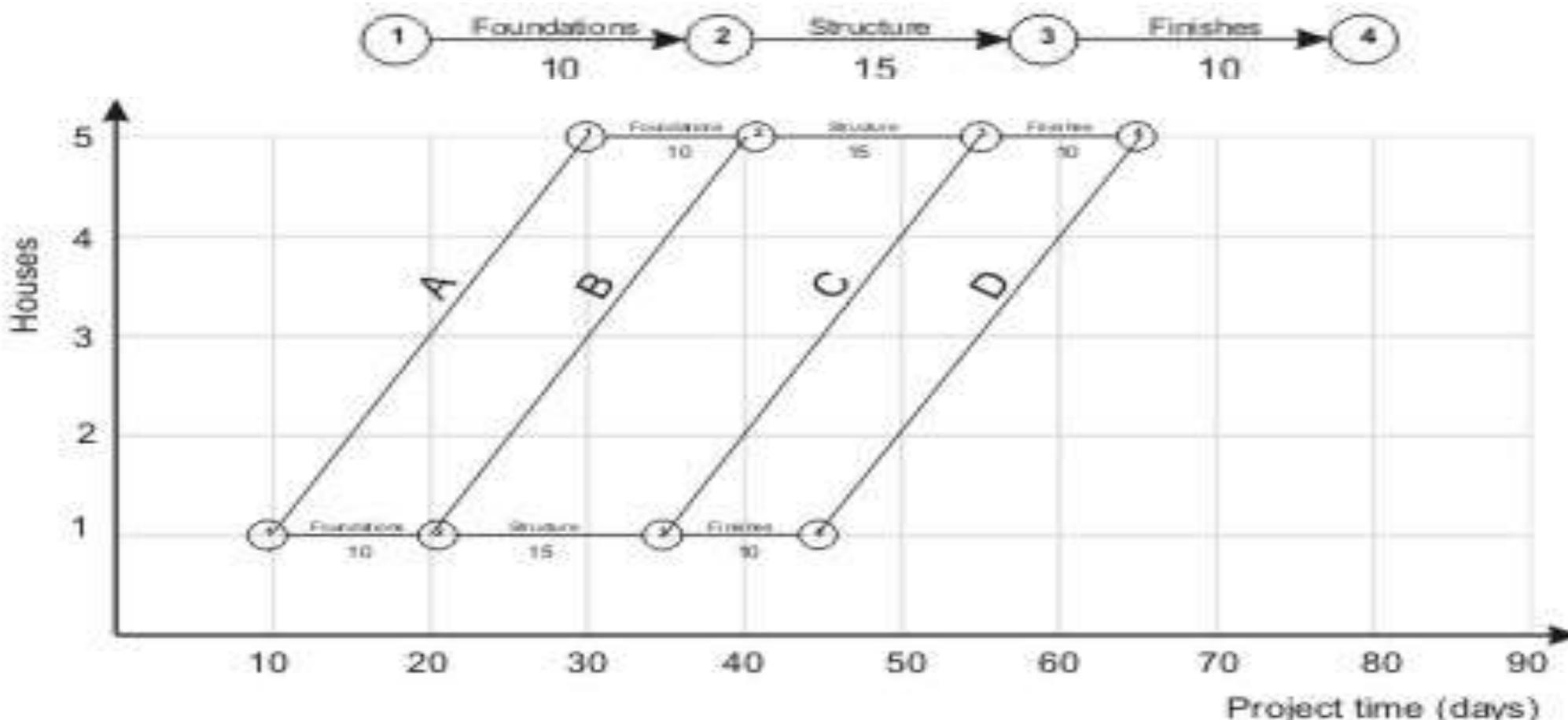


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  - continuous and aligned production
- Emphasis on controlling the work.
  - First, actual quantities placed in locations were monitored daily.
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# Basic Line-of-Balance

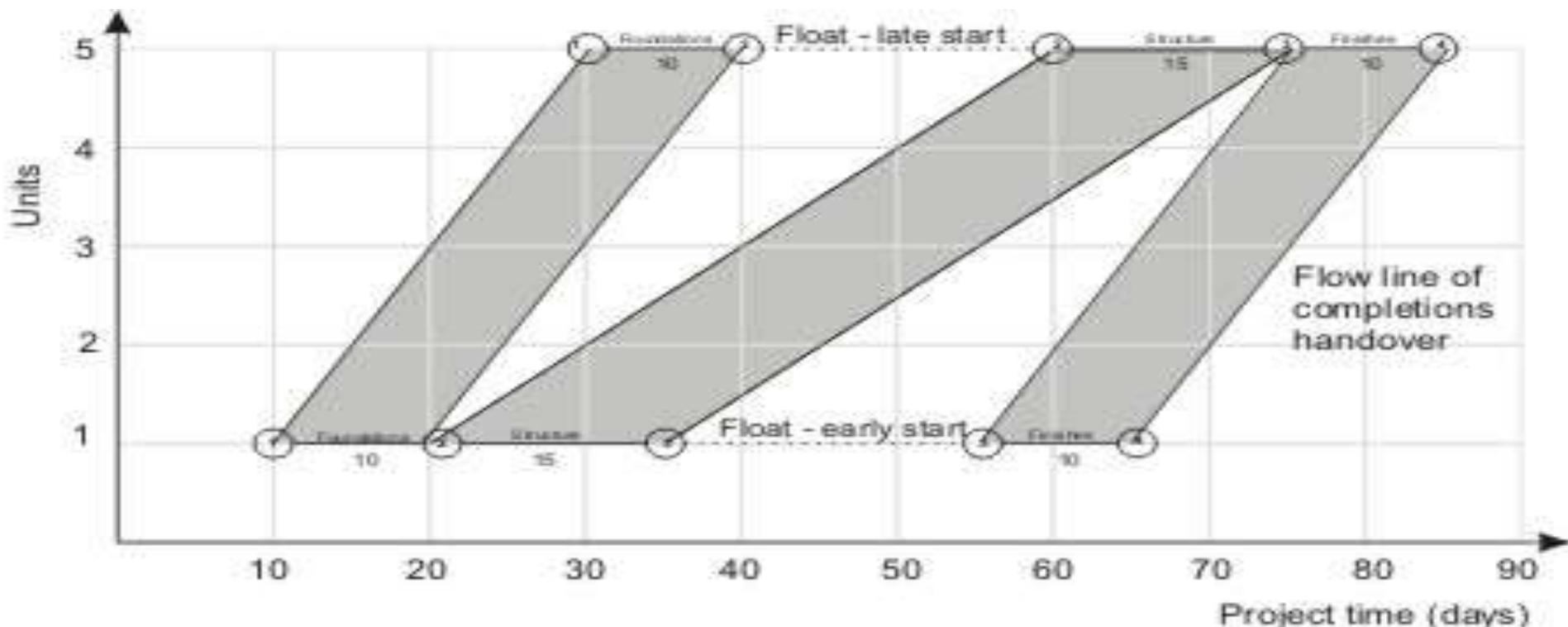


# Basic Line-of-Balance



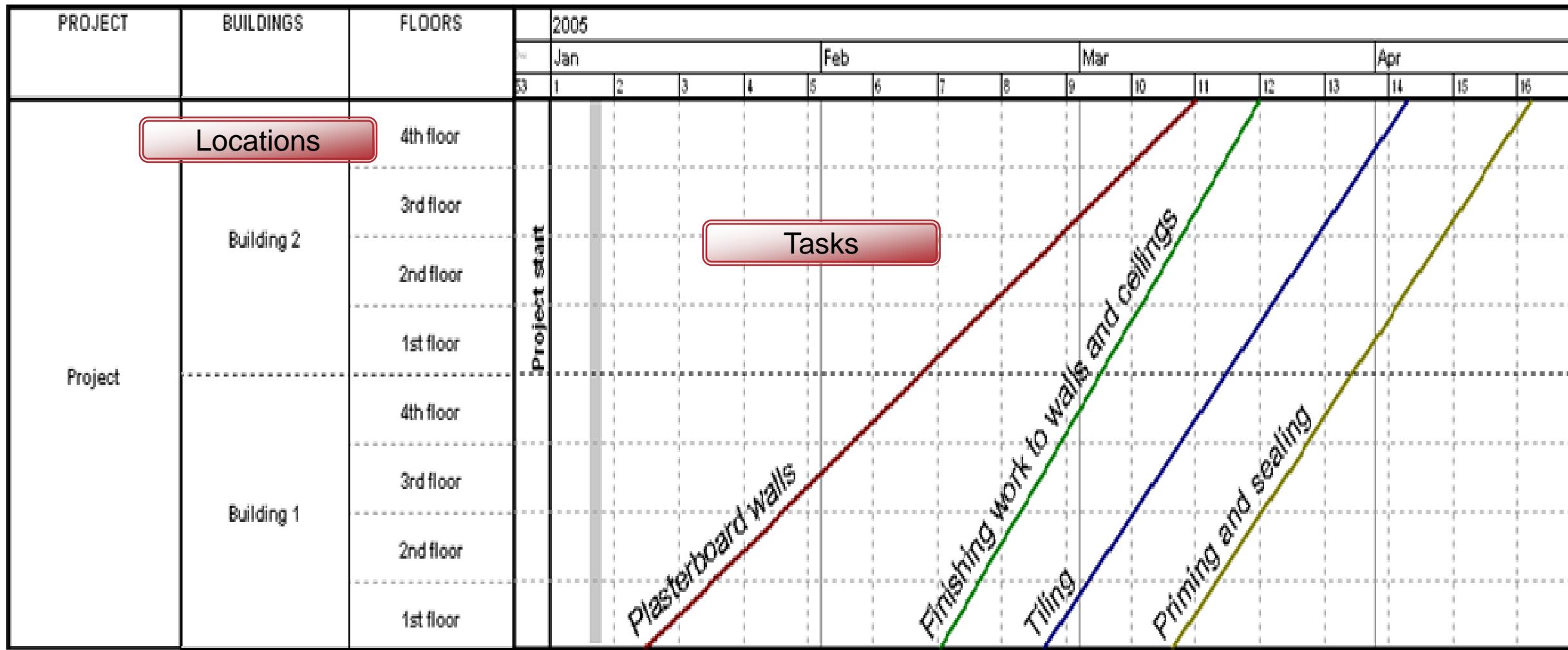
# Integrating CPM/LoB

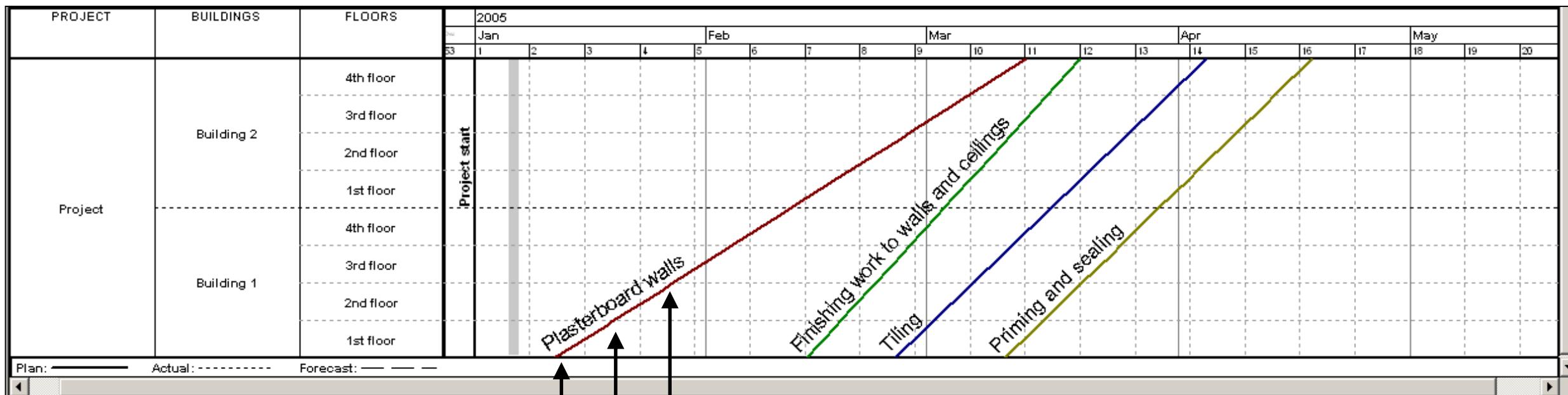
The relationship between the underlying logic (CPM) and the limits of the lines-of-balance



# Simple Flowline

Calendar





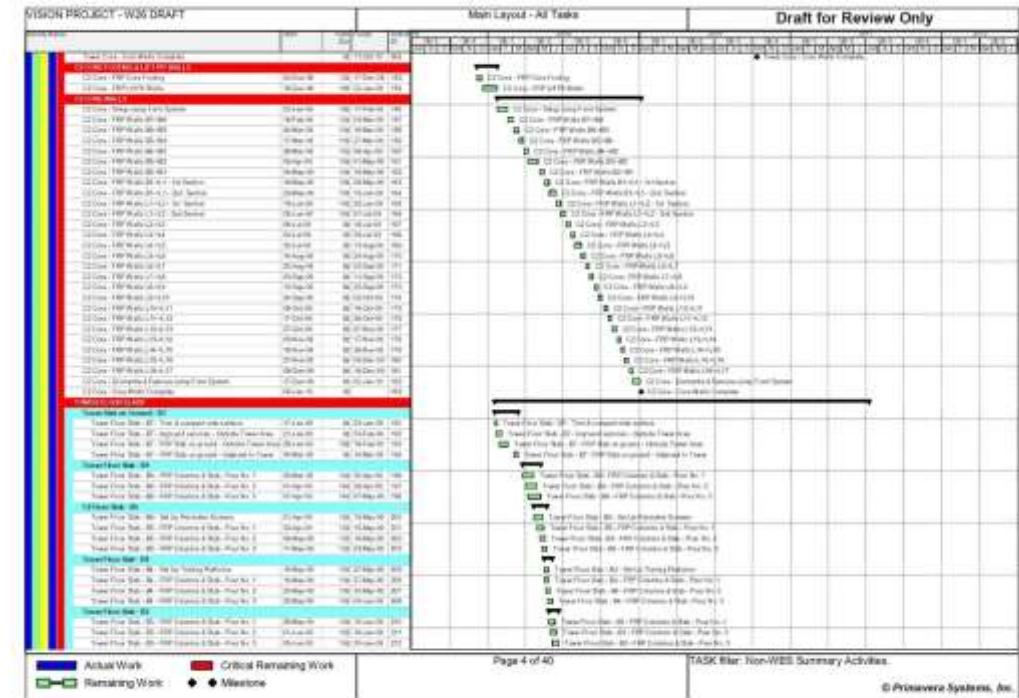
Plan: — Actual: - - - Forecast: — — —



# Case studies

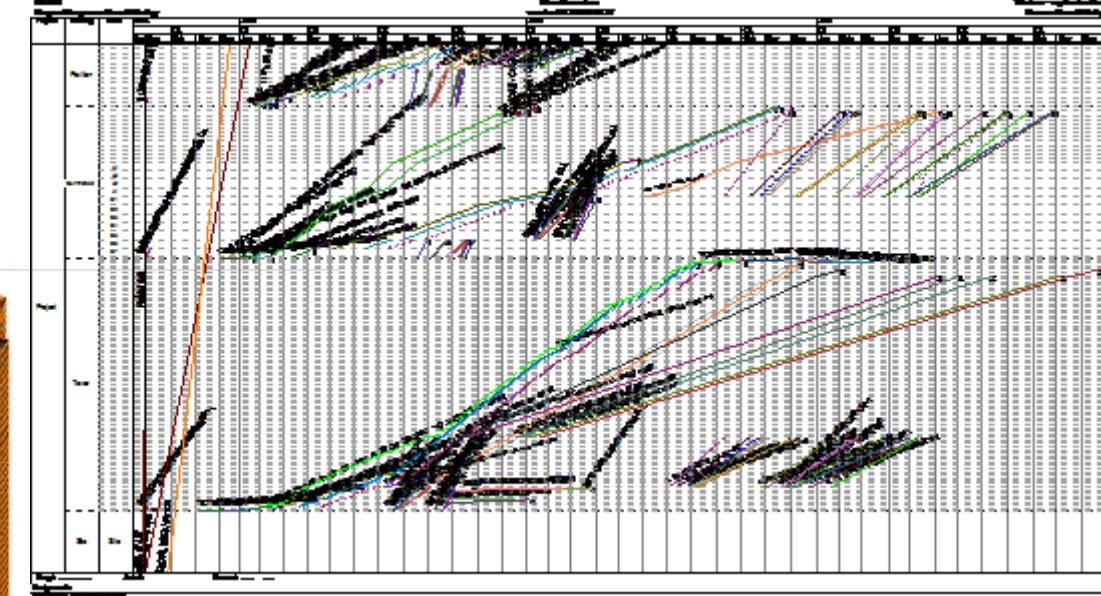
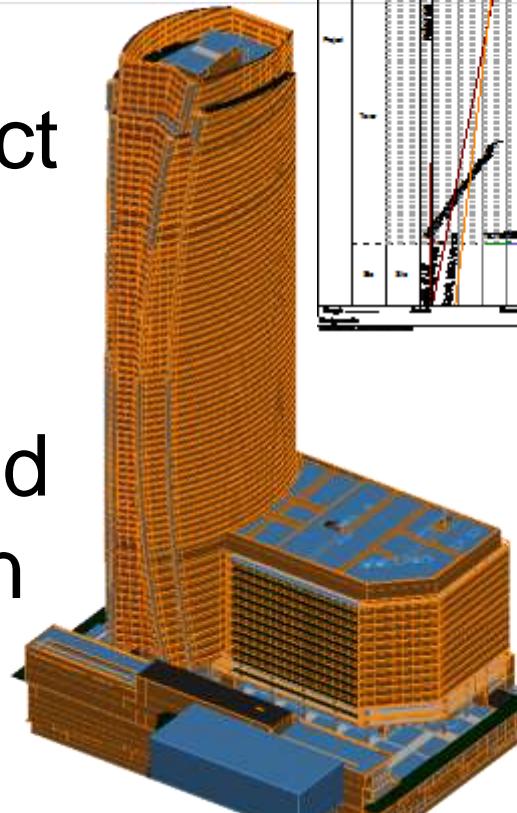
## Some issues that I have encountered while working with VDC

- Planning for structural cycles
- Planning for production efficiency
- Planning for problem solving
- Project monitoring and control
- Defensive scheduling
- Horizontal infrastructure



# Planning for structural cycles

- Planning a structural cycle should not be an accident.
- Location plays a critical role in determining project duration and resource efficiency.
- Here six months removed by changing the Location Breakdown Structure



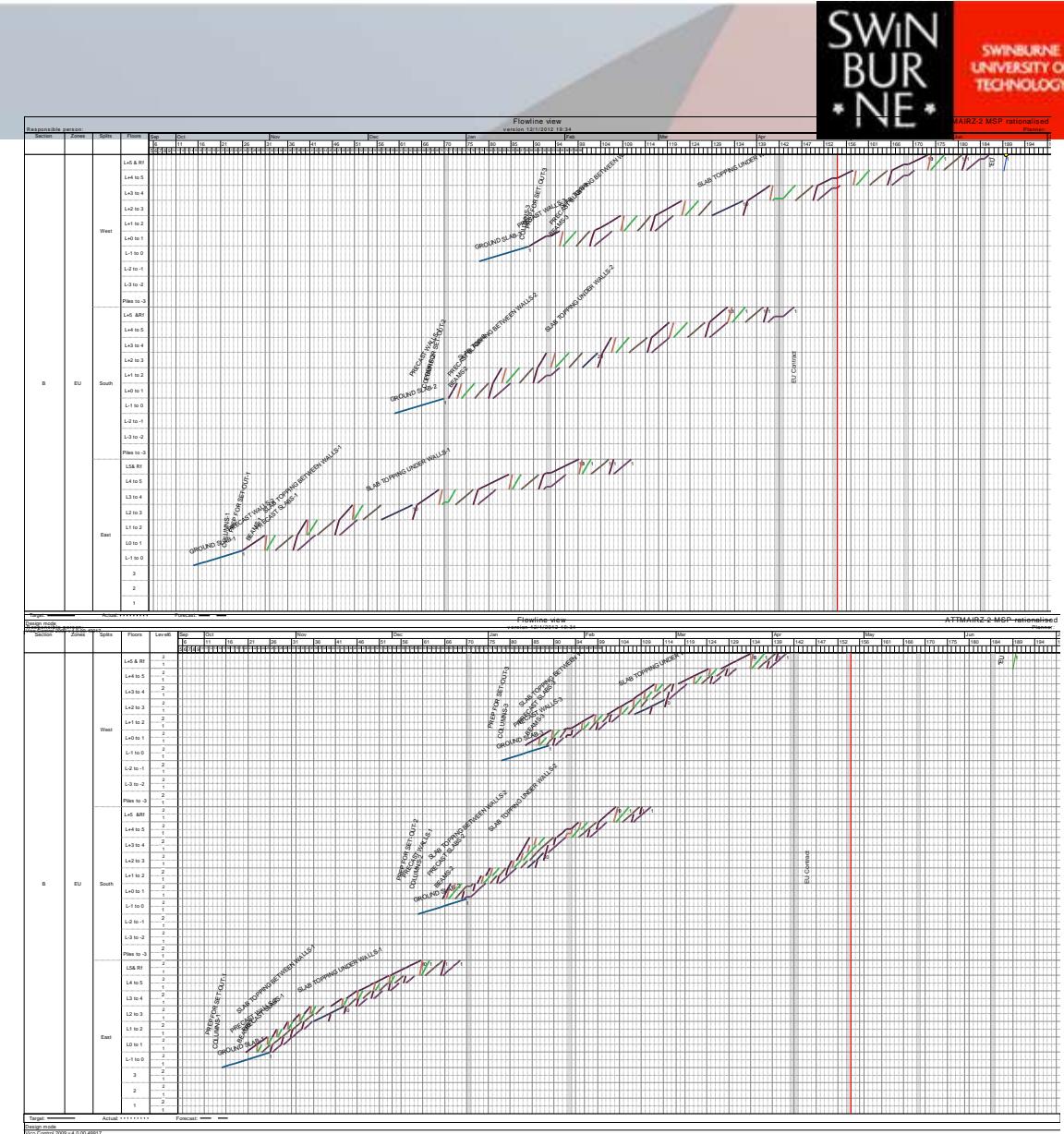
# Planning for structural cycles



- Removing waiting time by using a smaller cycle area



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# Planning for structural cycles

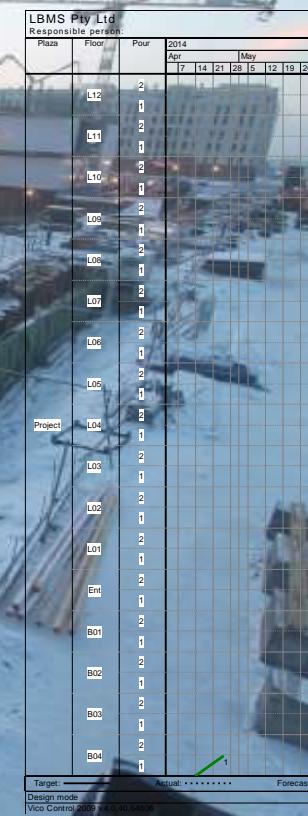


Sustainable  
Built Environment  
National Research Centre

WIN  
BUR  
NE\*

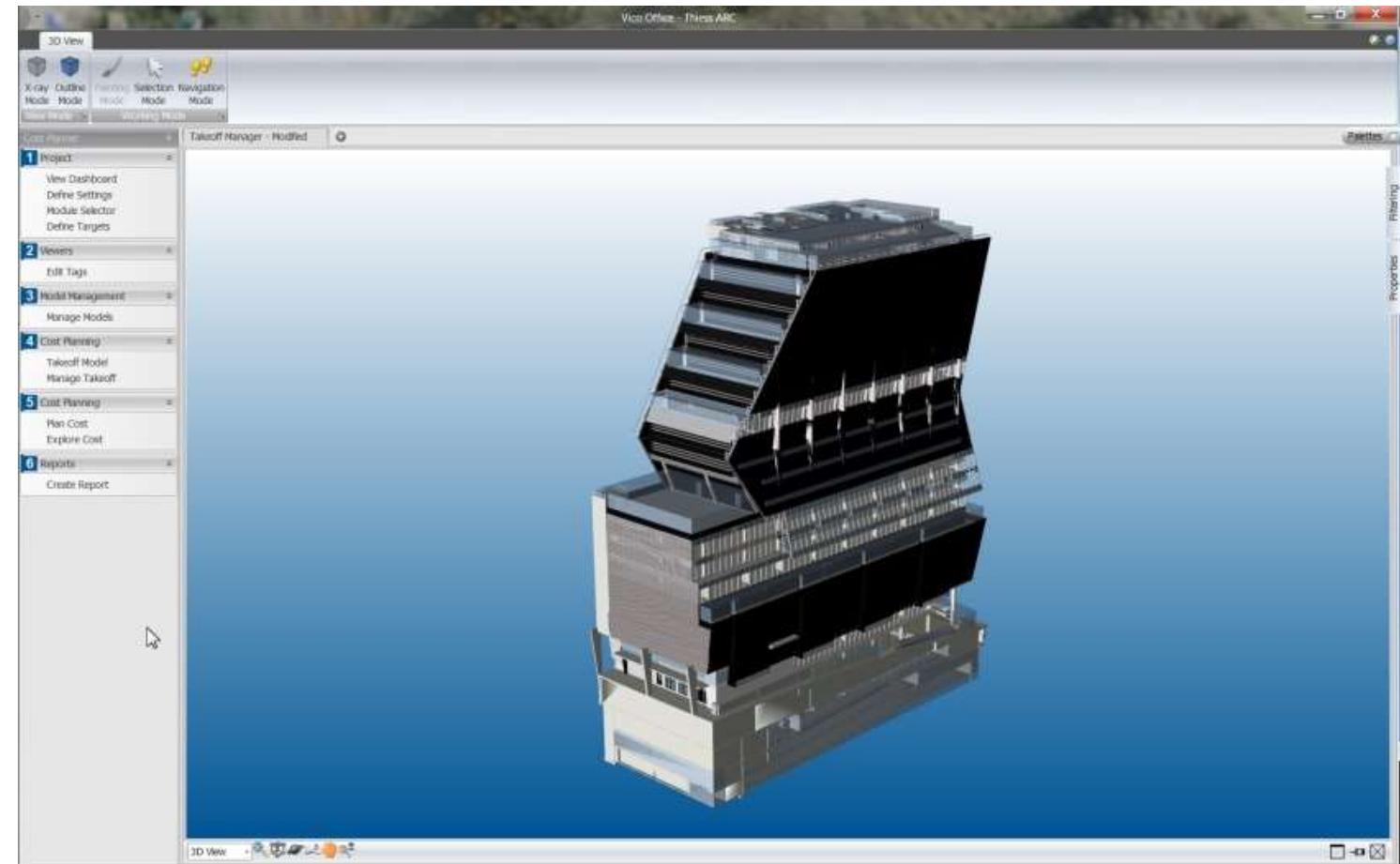
SWINBURNE  
UNIVERSITY OF  
TECHNOLOGY

- Splitting a pour but running them apart – why?



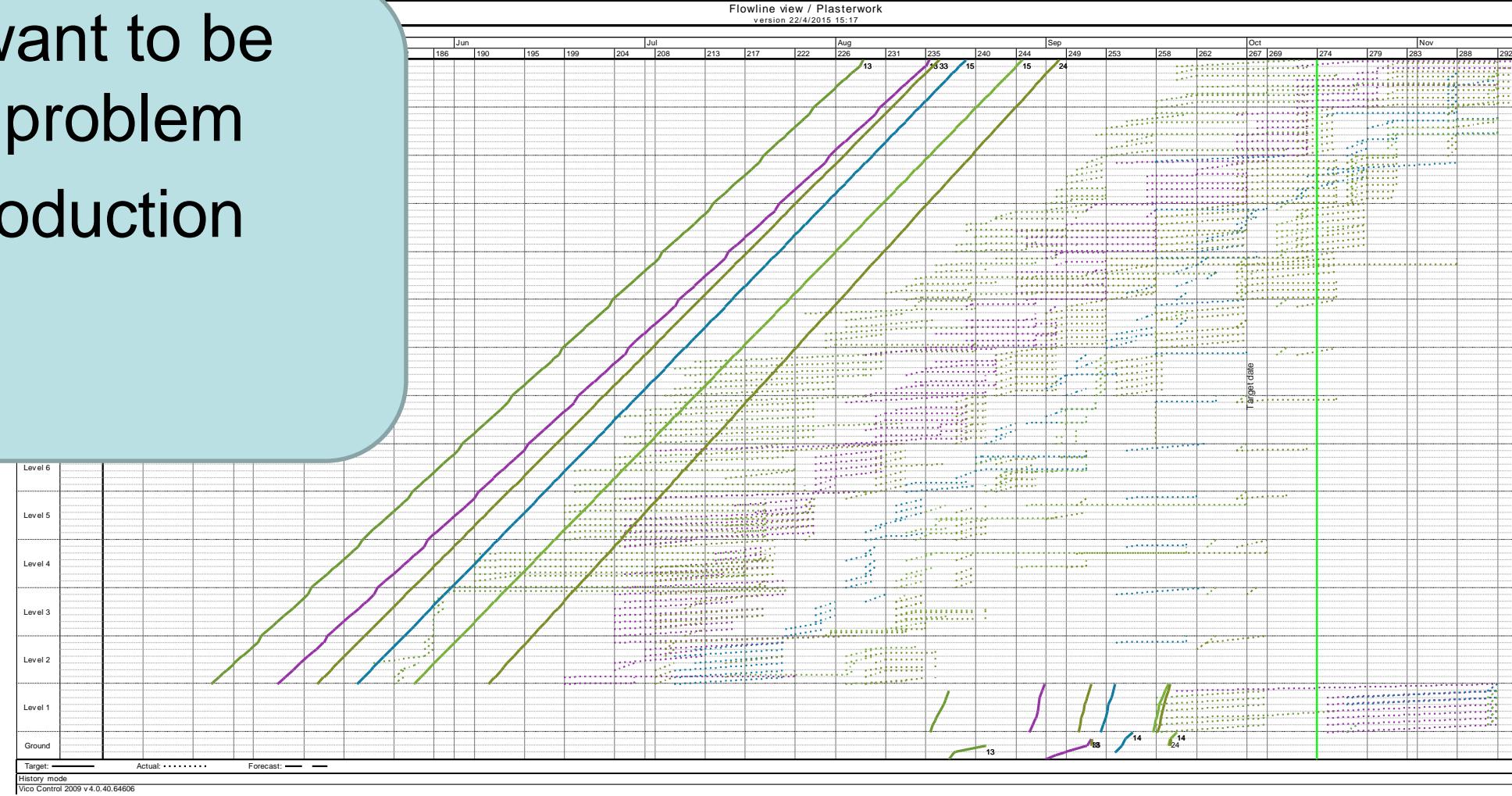
# Use 4D with care

- If you cannot see the fit-out inside a complex model
- How do you visualise the complexity of resource management



# Planning for production efficiency

- We don't want to be part of the problem
- Plan for production efficiency

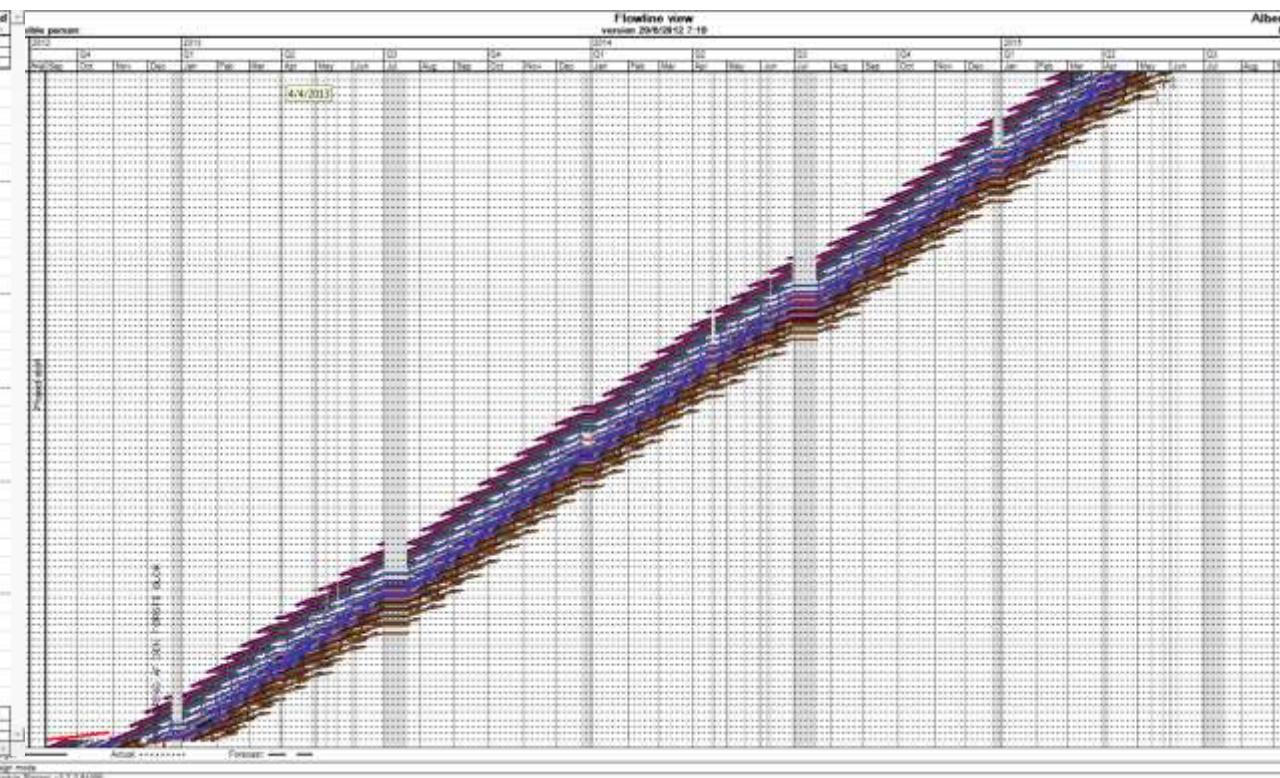
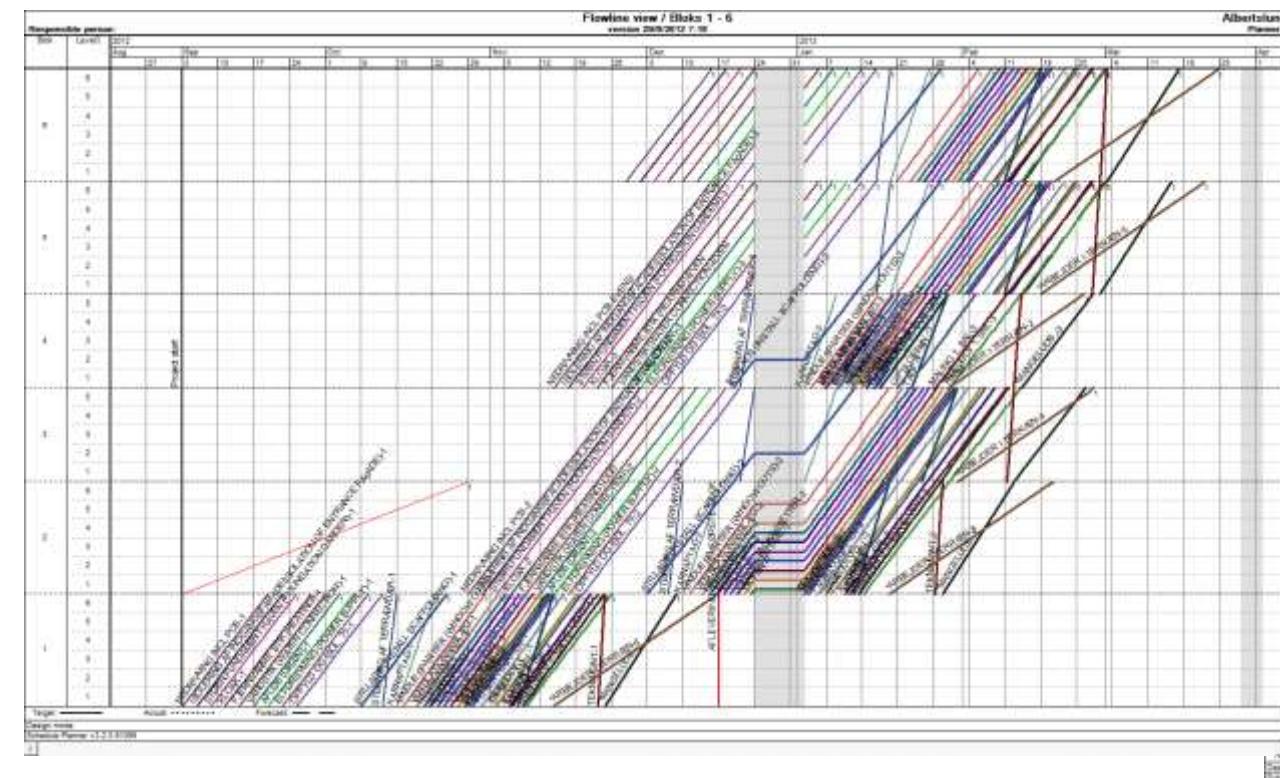


# Planning for problem solving



SWIN  
BUR  
\*NE\*

**SWINBURNE  
UNIVERSITY OF  
TECHNOLOGY**



# Project monitoring and control



- Contractors are displaying very bad practice when controlling projects
  - Poor logic with errors
    - Eg. Dangles, reverse logic
  - No baseline
  - Revising schedule every month
  - Not monitoring progress regularly
  - Poor status reports
  - No forecasting
    - Status is based on whether ahead or behind schedule (so always on schedule!)

Flowline view / Structure  
version 29/6/2012 6:16

GLOBE  
Planner: LBMS

The chart illustrates the construction timeline for a building across 17 floors. The Y-axis lists the floors from 'In ground' to '14 to 15'. The X-axis spans from August 2010 to August 2011. Construction activity is indicated by colored bars starting at various dates. A red dashed vertical line marks the beginning of 'STRUCTURE WALLS' on January 1, 2011. Labels on the chart include 'KEY POUR BASE LIFT PIT', 'STRUCTURE WALLS', and 'STRAFE WALLS'. A blue arrow points to 'LEVEL 1'.

Target: \_\_\_\_\_

Flowline view / Structure  
version 29/6/2012 6:18

GLOBE  
Planner: LBMS

START LEVEL

Target: \_\_\_\_\_ Actual: ..... Forecast: — —

## History mode

Schedule Planner v3.2.0.81099

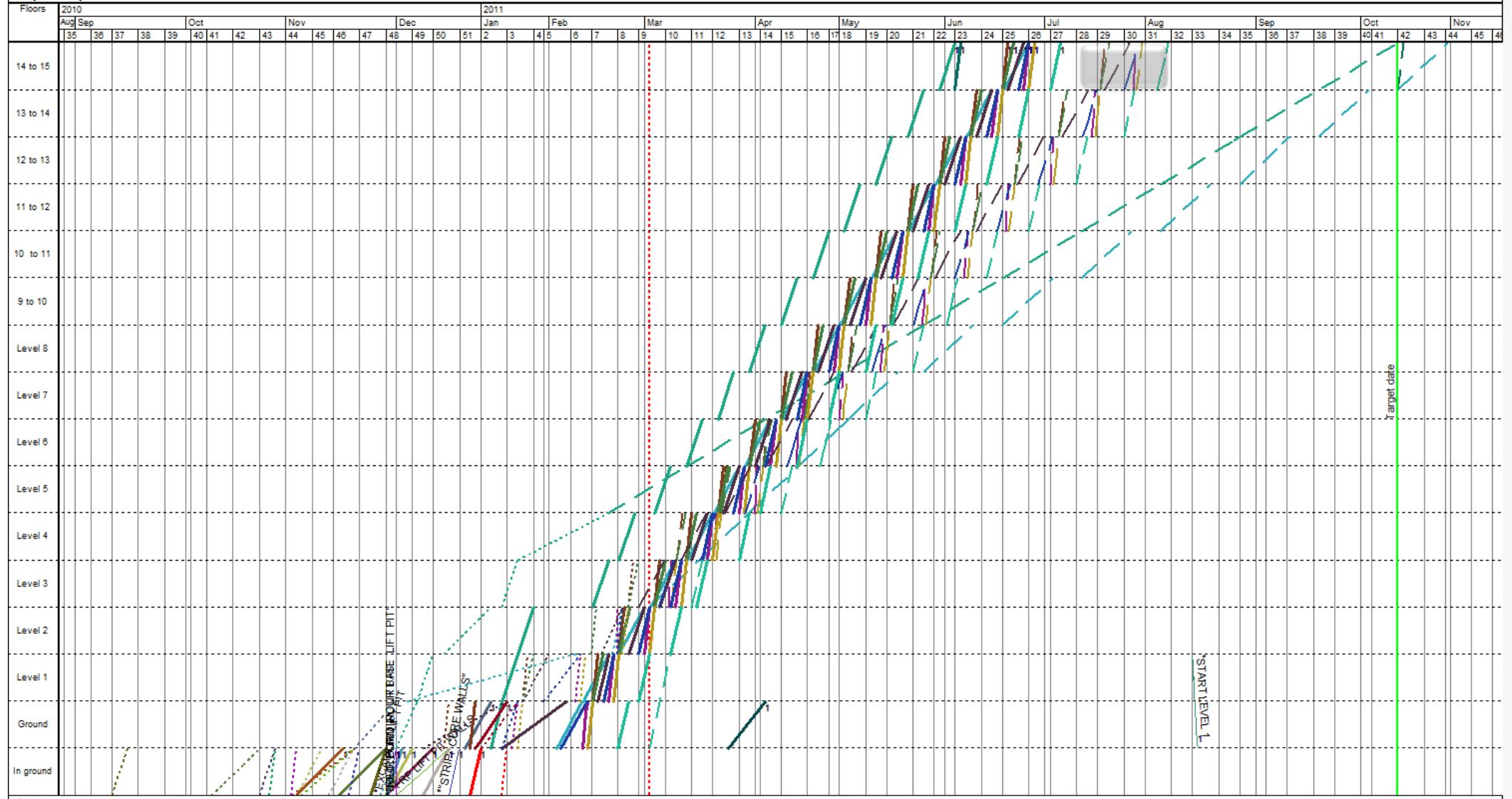
Flowline view / Structure  
version 29/6/2012 6:20

GLOBE  
Planner: LBMS

Target:   
History mode  
Schedule Planner v3.2.0.61099

Flowline view / Structure  
version 29/6/2012 6:21

Responsible person:

Target:  Actual:  Forecast: 

History mode

Schedule Planner v3.2.0.61099

Flowline view / Structure  
version 29/6/2012 6:23

GLOBE  
Planner: LBMS

The chart displays the status of various tasks over time. Most tasks have started by day 13, with significant delays occurring between days 14 and 25. A large cluster of tasks is scheduled for completion around day 30.

Day	Actual Progress	Forecast Progress
35	In ground	In ground
36	In ground	In ground
37	In ground	In ground
38	In ground	In ground
39	In ground	In ground
40	Ground	Ground
41	Ground	Ground
42	Ground	Ground
43	Ground	Ground
44	Ground	Ground
45	Ground	Ground
46	Ground	Ground
47	Ground	Ground
48	Ground	Ground
49	Ground	Ground
50	Ground	Ground
51	Ground	Ground
2	Ground	Ground
3	Ground	Ground
4	Level 1	Level 1
5	Level 1	Level 1
6	Level 1	Level 1
7	Level 1	Level 1
8	Level 1	Level 1
9	Level 1	Level 1
10	Level 1	Level 1
11	Level 1	Level 1
12	Level 1	Level 1
13	Level 1	Level 1
14	Level 1	Level 1
15	Level 1	Level 1
16	Level 1	Level 1
17	Level 1	Level 1
18	Level 1	Level 1
19	Level 1	Level 1
20	Level 1	Level 1
21	Level 1	Level 1
22	Level 1	Level 1
23	Level 1	Level 1
24	Level 1	Level 1
25	Level 1	Level 1
26	Level 1	Level 1
27	Level 1	Level 1
28	Level 1	Level 1
29	Level 1	Level 1
30	Level 1	Level 1
31	Level 1	Level 1
32	Level 1	Level 1
33	Level 1	Level 1
34	Level 1	Level 1
35	Level 1	Level 1
36	Level 1	Level 1
37	Level 1	Level 1
38	Level 1	Level 1
39	Level 1	Level 1

Target:  Actual:  Forecast:

Target: \_\_\_\_\_  
History mode  
Schedule Planner v3.2.0.61099

Flowline view / Structure  
version 29/6/2012 6:24

GLOBE  
Planner: LBMS

This Gantt chart illustrates the construction timeline for a building project across multiple floors from August 2010 to September 2011. The Y-axis lists the floors, and the X-axis shows the progression of time. Construction activities are tracked using colored bars and lines.

**Legend:**

- Vertical Lines:**
  - Red dashed line: End of May 2011
  - Green line: Start of Level 1
- Activity Types:**
  - Exterior walls (green)
  - Interior walls (blue)
  - Structural concrete (yellow)
  - Reinforcement (purple)
  - Formwork (orange)
  - Shoring (pink)
  - Excavation (grey)
  - Base lift pit (light blue)
  - Str-Concrete walls (dark blue)

**Key Labels:**

- EXCAVATION BASE LIFT PIT
- STRUCTURE
- STR-CONCRETE WALLS
- START LEVEL 1

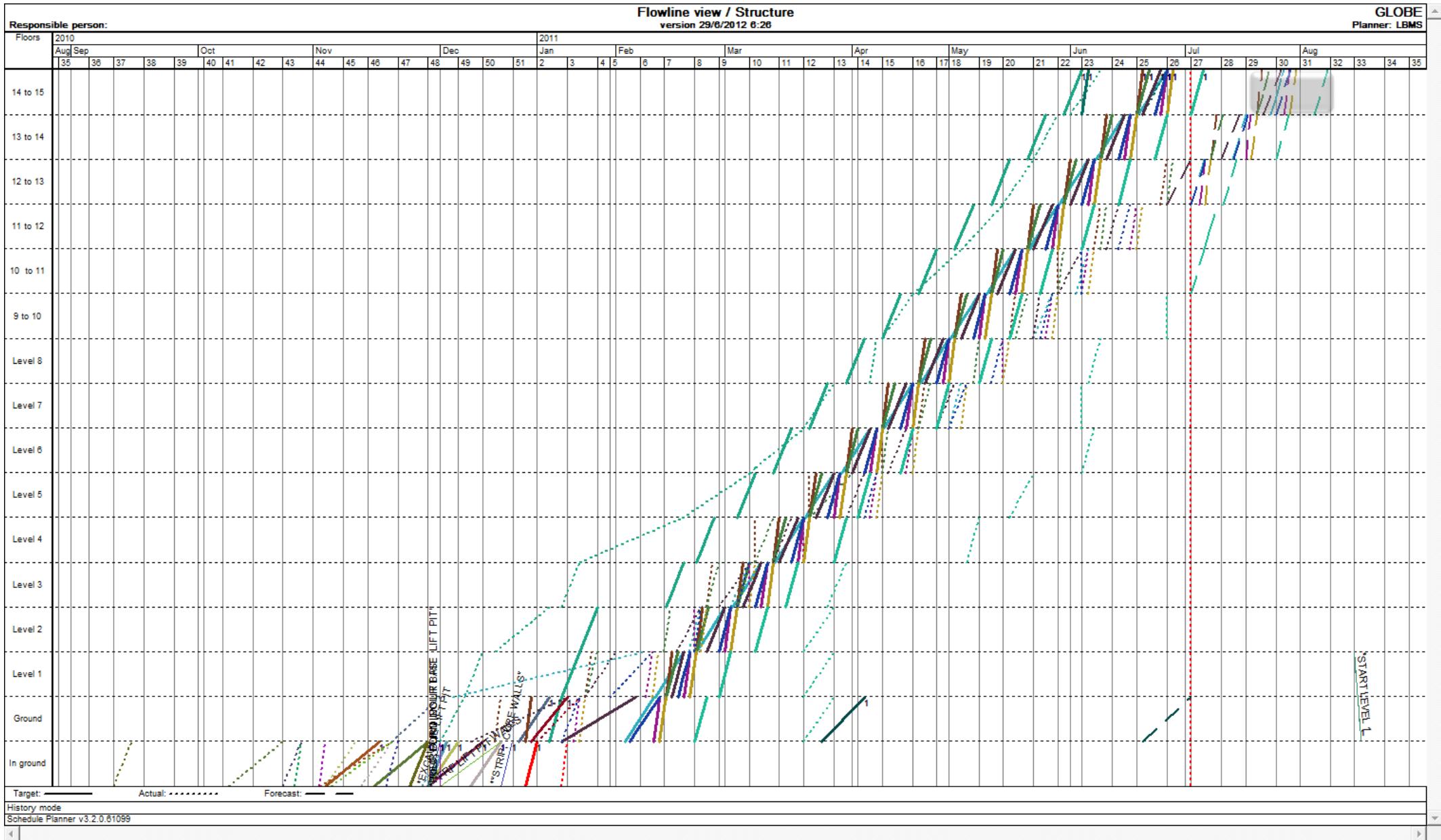
Target: \_\_\_\_\_  
History mode  
Schedule Planner v3.2.0.61099

Flowline view / Structure  
version 29/6/2012 6:25

GLOBE  
Planner: LBMS

The chart displays the construction progress for each floor over time. The Y-axis categories are: In ground, Ground, Level 1, Level 2, Level 3, Level 4, Level 5, Level 6, Level 7, Level 8, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, and 14 to 15. The X-axis shows months from Aug 2010 to Aug 2011. Construction activity is primarily visible from January 2011 onwards, with significant progress made on levels 1 through 14 by the end of the period shown.

Target:   
History mode  
Schedule Planner v3.2.0.61099



Flowline view / Structure  
version 29/6/2012 6:27

GLOBE  
Planner: LBMS

The chart displays the construction progress for various floors over time. The Y-axis categories are: In ground, Ground, Level 1, Level 2, Level 3, Level 4, Level 5, Level 6, Level 7, Level 8, 9 to 10, 10 to 11, 11 to 12, 12 to 13, 13 to 14, and 14 to 15. The X-axis shows months (Aug, Sep, Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep) and days (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37). Construction activities are represented by colored lines, with specific milestones labeled: 'STRUCTURE BASE LIFT PIT', 'STRUCTURE BASE', 'STRUCTURE', 'STRUCTURE TOP', and 'START LEVEL 1'. A red dashed vertical line marks the completion of 'STRUCTURE TOP' at Level 1. A green dashed line marks the start of 'STRUCTURE TOP' at Level 1. A grey shaded area covers the period from late July to early August.

Flowline view / Structure  
version 29/6/2012 6:28

GLOBE  
Planner: LBMS

This chart illustrates the construction progress of a building across multiple floors from August 2010 to September 2011. The vertical axis lists the floors, starting from 'In ground' at the bottom and ending at '14 to 15' at the top. The horizontal axis shows dates from Aug 35 to Sep 39. Colored lines represent the progress of various construction phases, including columns (green), beams (blue), and walls (yellow). Key milestones are marked with labels: 'EXCAVATION & POUR BASE LIFT PIT' (around Aug 40), 'STRUCTURE WALLS' (around Aug 45), and 'START LEVEL' (around Sep 28). A red dashed vertical line at the end of the timeline indicates the completion date of September 30, 2011.

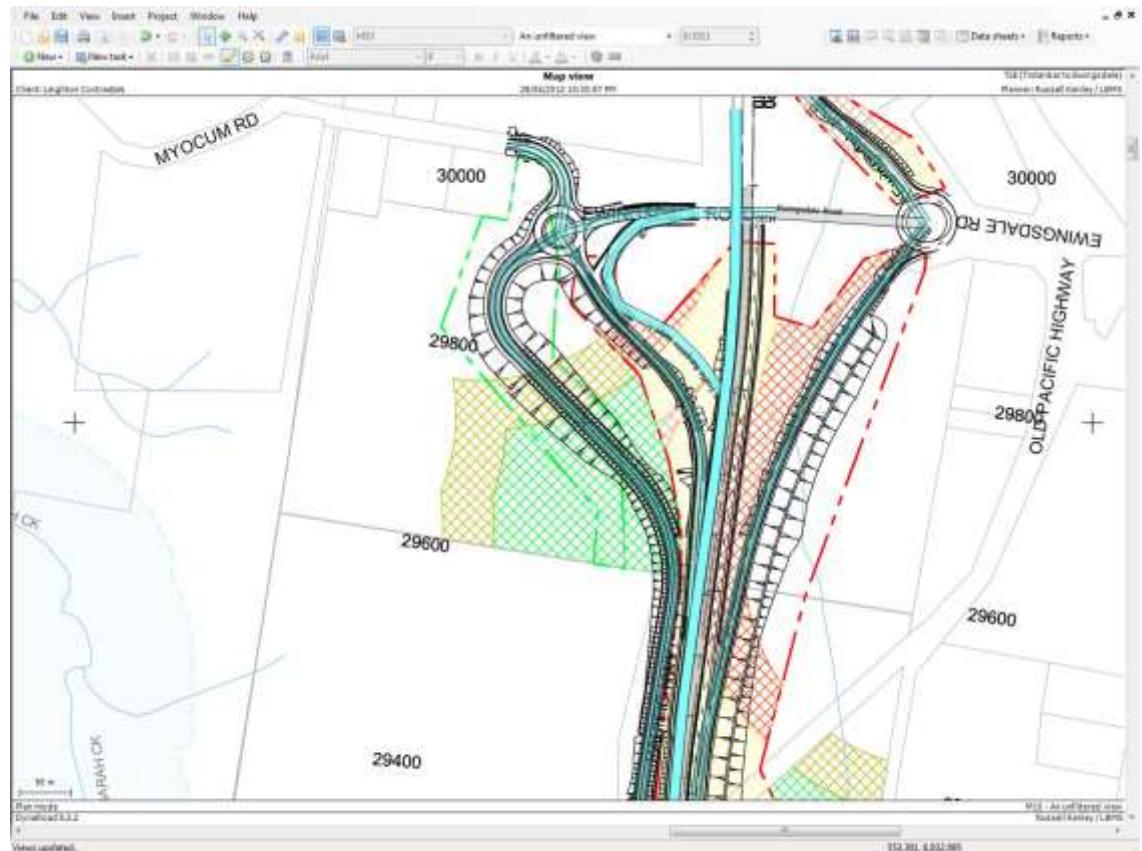
Target:   
History mode  
Schedule Planner v3.2.0.61099

# Rapid scheduling

- Rapid prototyping



# Horizontal infrastructure



- Alignment based
- Real-world coordi

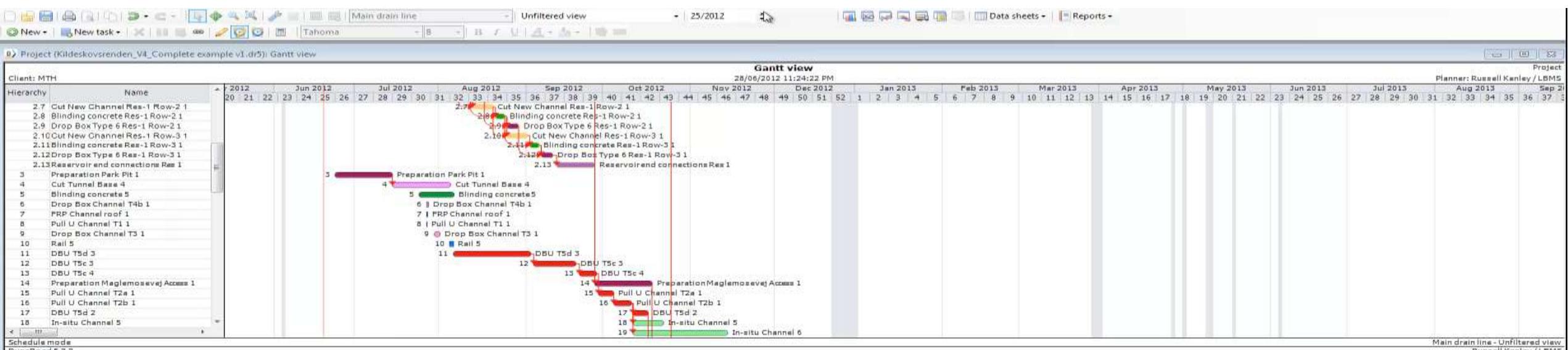


# Horizontal infrastructure



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# Horizontal infrastructure



# Distributed Construction or Maintenance

- Distributed work involves location
- Resources can be managed across locations
- Management by location should be explicit
- Partnering with MPI to create new *Location* functionality for CPM



# Questions?

